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REPORT OF THE BOARD

ON BEHALF OF

UNITED STATES EXECUTIVE DEPARTMENTS

AT THE

INTERNATIONAL EXHIBITION,

HELD AT

PHILADELPHIA, PA., 1876,

UNDER ACTS OF CONGRESS OF MARCH 3, 1875, AND MAY 1, 1876.

80980 a.

IN TWO VOLUMES.

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VOL. I.

This volume is Volume X of the series of Reports on the International Exhibition of 1876, heretofore published by Congress under joint resolution of June 20, 1879.

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MESSAGE

FROM THE

PRESIDENT OF THE UNITED STATES,

TRANSMITTING THE REPORT OF THE BOARD ON BEHALF OF UNITED STATES EXECUTIVE DEPARTMENTS AT THE INTERNATIONAL EXHIBITION, 1876.

FEBRUARY 1, 1877.—Referred to the Committee on Public Buildings and Grounds and ordered to be printed.

FEBRUARY 1, 1877.—Committee on Public Buildings and Grounds discharged and referred to the Committee on Printing.

To the Senate and House of Representatives:

I transmit, herewith, the catalogues and report of the Board on behalf of the Executive Departments at the International Exhibition of 1876, with their accompanying illustrations.

The labors performed by the members of the Board, as evinced by the voluminous mass of information found in the various papers from the officers charged with their preparation, have been, in the highest degree, commendable; and believing that the publication of these papers will form an interesting memorial of the greatest of International Exhibitions, and of the Centennial Anniversary of the Independence of our country, I recommend that they be printed in a suitable form for distribution and preservation.

The letter of the chairman of the Board will give to Congress the history of its organization, the laws and Executive orders under which it has acted, and the steps which have been taken to preserve the large and instructive collections made, with a view to their forming a part of a National Museum, should Congress make the necessary appropriations for such a desirable object.

U. S. GRANT.

EXECUTIVE MANSION, *February* 9, 1877.

[PUBLIC RESOLUTION—NO. 19.]

JOINT RESOLUTION to print five thousand copies of the report of the Board on behalf of the United States Executive Departments at the International Exhibition of eighteen hundred and seventy-six.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That there be printed and bound, in continuation of the series of volumes heretofore published by Congress under joint resolution of June twentieth, eighteen hundred and seventy-nine, containing the final report of the United States Centennial Commission on the International Exhibition of eighteen hundred and seventy-six, and uniform therewith, five thousand copies of the report of the Board on behalf of the United States Executive Departments at said Exhibition, being the report which was submitted to Congress by the President of the United States, by special message of February ninth, eighteen hundred and seventy-seven, and again in his annual message of December third, eighteen hundred and seventy-seven, of which number three thousand copies shall be for the House, one thousand copies for the Senate, two hundred copies for the Smithsonian Institution for distribution to such foreign Governments and others as made contributions from such exhibition to the National Museum, three hundred copies for the late members of said Board, and five hundred copies for distribution by the late president of the Centennial Commission, the printing to be done by the Public Printer, under the supervision of the late chairman of said Board, upon whose order may be allowed by the Public Printer to the late secretary of the Board not exceeding three hundred dollars for services to be performed, and incidental expenses to be incurred in connection therewith: *Provided*, That the photographic views of the government exhibit accompanying the manuscript report, shall not be printed or reproduced for the publication herein authorized.

Approved, March 3, 1883.

UNITED STATES GOVERNMENT PARTICIPATION

IN THE

INTERNATIONAL EXHIBITION, 1876.

OFFICE OF THE BOARD ON BEHALF OF
UNITED STATES EXECUTIVE DEPARTMENTS,
No. 1735 F STREET N. W.,
Washington, D. C., February 6, 1877.

The PRESIDENT OF THE UNITED STATES:

SIR: I am directed by the Board on behalf of the United States Executive Departments at the International Exhibition of 1876 to submit the following report:

The participation of the Government in the Exhibition was preliminarily undertaken by this Board in pursuance of the following order, viz:

[Executive Order.]

INTERNATIONAL EXHIBITION, 1876.

BY THE PRESIDENT OF THE UNITED STATES.

Whereas it has been brought to the notice of the President of the United States that, in the International Exhibition of Arts, Manufactures, and Products of the Soil and Mine, to be held in the city of Philadelphia, in the year eighteen hundred and seventy-six, for the purpose of celebrating the one hundredth anniversary of the Independence of the United States, it is desirable that from the Executive Departments of the Government of the United States, in which there may be articles suitable for the purpose intended, there should appear such articles and materials as will, when presented in a collective exhibition, illustrate the functions and administrative faculties of the Government in time of peace and its resources as a war power, and thereby serve to demonstrate the nature of our institutions and their adaptations to the wants of the people.

Now, for the purpose of securing a complete and harmonious arrangement of the articles and materials designed to be exhibited from the Executive Departments of the Government, it is ordered that a Board, to be composed of one person to be named by the head of each of the Executive Departments which may have articles and materials to be exhibited, and also of one person to be named in behalf of the Smithsonian Institution, and one to be named in behalf of the Department of Agriculture, be charged with the preparation, arrangement, and safe-keeping of such articles and materials as the heads of the several Departments and the Commissioner of Agriculture and the Director of the Smithsonian Institution may respectively decide shall be embraced in the collection; that one of the persons thus named, to be designated by the President, shall be chairman of such Board, and that the Board appoint from their own number such other officers as they may think necessary; and that the said Board, when organized, be authorized, under the direction of the President, to confer with executive

officers of the Centennial Exhibition in relation to such matters connected with the subject as may pertain to the respective Departments having articles and materials on exhibition; and that the names of the persons thus selected by the heads of the several Departments, the Commissioner of Agriculture and the Director of the Smithsonian Institution, shall be submitted to the President for designation.

By order of the President:

HAMILTON FISH,
Secretary of State.

WASHINGTON, *January* 23, 1874.

In accordance with this order the following persons were named by the heads of the several Departments, &c., mentioned in the order having articles or materials to be exhibited, to compose the Board, viz:

By the Secretary of the Treasury....Hon. R. W. TAYLER.*
By the Secretary of War.....Col. S. C. LYFORD, U. S. A.
By the Secretary of the Navy.....Admiral T. A. JENKINS, U. S. N.
By the Secretary of the Interior.....JOHN EATON, Esq.
By the Postmaster-General.....Dr. CHAS. F. MACDONALD.
By the Department of Agriculture...WM. SAUNDERS, Esq.
By the Smithsonian Institution.....Prof. S. F. BAIRD.

Col. S. C. Lyford was designated by the President to be chairman of the Board.

These appointments were not announced by the Department of State until March 25, 1874, and the first meeting of the Board was held April 10, 1874, when it was concluded, after discussion, that each member should have full and exclusive control of the matters pertaining to his particular Department, subject to the general advisement of the Board, and that immediate steps should be taken to ascertain the amount of space required at the Exhibition for the several Departments, and the probable cost of the entire undertaking.

During the remainder of the year 1874 the several members of the Board matured their plans, comprehending the nature and extent of effective participation, and prepared their estimates of cost. These estimates, which were submitted to Congress on January 8, 1875, aggregated the sum of $971,000, in which was included an item of $200,000 for a building at Philadelphia capable of removal to Washington after the close of the Exhibition, to be used as a National Museum. The wisdom of the Board in forecasting at the time the probable demands of the public service after the close of the Exhibition, in respect to storage facilities for the collections made by it, is now confirmed by the demands which it is reluctantly compelled to make on Congress for that which it sought in the first instance to provide for.

The appropriations for the purposes of the Board were not made until March 3, 1875, and were, in the cases of the War, Navy, and Smith-

* Hon. F. M. Sawyer, Assistant Secretary of the Treasury, was at first appointed to represent the Treasury Department in the Board; upon his resignation Hon. R. W. Tayler, First Comptroller, was appointed in the Board in his stead.

sonian Institution, only two-thirds of the estimated amounts needed; while in the case of the Interior Department, the appropriation was but little more than half of what was asked for. The appropriations were as follows, in the "act making appropriations for sundry civil expenses of the Government for the fiscal year ending June 30, 1876, and for other purposes," approved March 3, 1875, viz:

SEC. 5. To enable the Executive Departments of the Government and the Smithsonian Institution to participate in the International Exhibition of eighteen hundred and seventy-six, the following sums are hereby appropriated, namely: For the Interior Department, one hundred and fifteen thousand dollars; for the Treasury Department, five thousand dollars; for the Post-Office Department, five thousand dollars; for the Agricultural Department, fifty thousand dollars; for the Smithsonian Institution, sixty-seven thousand dollars; for the United States Commission of Food-Fishes, five thousand dollars; for the War Department, one hundred and thirty-three thousand dollars; for the Navy Department, one hundred thousand dollars; for show-cases, shelving, stationery, postage, telegrams, expressage, and other necessary incidental expenses, twenty-five thousand dollars; in all five hundred and five thousand dollars; to be disbursed under the direction of the Board on Executive Departments appointed in pursuance of the presidential order of January twenty-third, eighteen hundred and seventy-four. And authority is hereby given to the heads of the several Executive Departments to display at the International Exhibition of eighteen hundred and seventy-six, under such conditions as they may prescribe, subject to the provisions of section seven of the act of June first, eighteen hundred and seventy-two, all such articles in store or under the control of said Departments as may be necessary or desirable to render such collection complete and exhaustive: *Provided*, That should it become necessary to erect any building or part of a building, for said Exhibition, on the part of the Government, the same shall be paid for, pro rata, out of the sums appropriated to the several Departments, the United States Commission of Food-Fishes and the Treasury and Post-Office Departments excepted, the cost of the building not to exceed one hundred and fifty thousand dollars; and at the close of the Exhibition, said building shall be sold and the proceeds covered into the Treasury as miscellaneous receipts: *And provided further*, That the sums hereby appropriated shall cover the entire expense to which the United States Government shall be subjected on account of said Exhibition, except the sum appropriated in this act for printing the certificates of stock of said Exhibition; and the Board on Executive Departments is forbidden to expend any larger sum than is set down herein for each Department, or to enter into any contract or engagement that shall result in any such increased expenditure; and no money shall be taken by any Department for the purposes of this Exhibition as aforesaid from any other appropriations except the one hereby made: *And further provided*, That of the sum hereby appropriated the sum of two hundred thousand dollars shall be immediately available.

On March 9, 1875, the following Executive order was issued, viz:

EXECUTIVE MANSION, *March* 9, 1875.

In order to carry out the provisions of the fifth section of the act of Congress entitled "An act making appropriations for sundry civil expenses of the Government for the fiscal year ending June 30, 1876, and for other purposes," approved March 3, 1875, the Board heretofore appointed to take charge of the articles and materials to be exhibited by the several Executive Departments, the Smithsonian Institution, and the Agricultural Department at the International Exhibition of 1876, is hereby continued under the following regulations and distribution of duties, viz:

The funds appropriated by the above-named section will be drawn from the Treasury upon the requisition of the chairman of the Board, and to be disbursed as are other public moneys under the existing laws relating to disbursing officers.

An officer of the Army will be detailed by the Secretary of War as disbursing officer of the Board.

Each representative of an Executive Department, and the representative of the Smithsonian Institution, of the Agricultural Department, and the United States Commissioner of Food-Fishes will have charge of the matters pertaining to his respective Department, subject to the general advisement of the Board; and all bills will be paid by the disbursing officer upon vouchers certified by such representative and countersigned by the chairman of the Board.

The disbursing officer will render monthly accounts-current of all advances to and disbursements by him to the First Auditor of the Treasury, for audit and settlement in the same manner as are other accounts of disbursing officers of the Government.

Each representative will be held responsible to the head of his respective Department for all public property of the United States furnished by the head of such Department or otherwise coming to his hands for the purposes of the Exhibition, and will render proper accounts of the same to such head of Department until the property is returned.

U. S. GRANT,
President United States.

In pursuance of the foregoing order, the Secretary of War, by order dated March 10, 1875, detailed Capt. Jos. S. Conrad, Second United States Infantry, brevet colonel U. S. A., as disbursing officer of the Board. This officer entered upon his duties immediately, and has disbursed the funds of the Board in a manner that has given great satisfaction to the public creditors.

On March 12, 1875, the President, on the recommendation of the chairman, approved the designation of Mr. William A. DeCaindry to act as secretary of the Board. Mr. DeCaindry, by his zeal and assiduous attention to the business of the Board, has lightened its labors and enabled it to bring its work to its present satisfactory conclusion; and in thus expressing the views of the Board, I must acknowledge my own personal indebtedness to him from the inception of the undertaking for the clear and able manner in which he has presented the action of the Board in its various reports and correspondence, and for his always judicious advice so frequently used.

Immediately upon the passing of the appropriations in 1875 efforts were made by the Board to induce the Exhibition authorities to erect, out of their funds, a special building for the accommodation of the Governmental display, but without avail. On July 1, 1875, the Board adopted a plan of building suitable for the United States collection, designed by James H. Windrim, architect, of Philadelphia, to be erected out of the funds appropriated by Congress. As originally brought before the Board, the plan contemplated a floor space of only 83,640 square feet, but it was subsequently enlarged so as to increase the floor space to 102,840 square feet; and the contract for erecting the structure was awarded to A. Doan & Co., contractors and builders, of Philadelphia, by the building committee appointed by the Board, composed of Colonel Lyford, Admiral Jenkins, and William Saunders, esq., competitive bids for the work having previously been obtained. Herewith accompanying

are submitted detailed plans, specifications, and perspective drawings of the building as erected on the Exhibition grounds.

The breaking of ground was commenced in Fairmount Park, in July, 1875, immediately upon the assignment of space to the Government by the Centennial authorities. The work of construction steadily progressed during the summer, fall, and winter of 1875, and the building was ready for the acceptance of the building committee, finished in all its parts, on March 1, 1876. The execution of the contract by the builders was in the highest degree satisfactory, and reflected great credit on them as thorough and efficient workmen and staunch business men. The total cost of the structure upon its acceptance on March 1, 1876, was $80,817.71, and no additional expense has been incurred since that date under that head. The amount authorized by Congress to be expended on the building was $150,000.

The construction of the building was supervised by First Lieut. Henry Metcalfe, Ordnance Department, who was appointed by the chairman supervisor of construction, and who discharged the duties in connection with this appointment in a very competent and satisfactory manner. On January 1, 1876, he was appointed by the chairman executive officer at the building, in addition to his connection with the ordnance section of the War Department display; and in virtue thereof was charged with the permanent superintendence and charge, under the guidance and direction of the chairman, of all matters relating to police and guard, and with the care and preservation of the building and grounds. It is due to this officer to say, and I take great pleasure in doing so, that I consider the great success of the governmental exhibition, and the favor and commendation with which it was received by the public (as evinced by the many exceedingly complimentary notices in the public press), to be due in the greatest degree to his efforts to administer the many duties assigned him in a manner that should secure the most harmonious working of the diverse interests involved, and to the exercise of his clear judgment in executing his many, and sometimes embarrassing, orders.

Arrangements were made early in December, 1875, by which Capt. John F. Rodgers, Quartermaster's Department, was stationed at the Government building for the receipt of all articles sent on behalf of the Government, and for reshipping them to places of final deposit after the close of the Exhibition. Captain Rodgers effected arrangements with the various railroad companies throughout the country whereby the special freight rates of the Exhibition conceded to the general public were extended to the Government materials, with the further concession that prepayment of charges should not be exacted, as in case of the public at large. The system of labeling adopted by the Centennial Commission was adopted by the Government, with such minor modifications as were deemed expedient. Each Department was provided with its own distinctive labels; the bills of lading and invoices and the methods of transmission conformed as nearly as possible to the forms

prescribed by the Quartermaster's Department of the Army. By the system of marking adopted, each packing-box was easily stored and reclaimed for reshipping the identical goods at the close of the Exhibition. The boxing belonging to all the Departments was taken charge of by Captain Rodgers and stored at the Philadelphia depot of the Quartermaster's Department, permission for the use of available warehousing at the post having been kindly granted by the Secretary of War, upon the recommendation of the Quartermaster-General. All packages were unloaded directly from the cars into the building, a track having been especially laid for the purpose, and were placed in such positions as were most convenient to the persons in charge of installation in the several Departments.

Each Department was charged with the freight on its own materials, the freight bills being made out by Captain Rodgers, and forwarded through the several representatives in the Board to the chairman for payment.

The receipt of articles began at the building about January 1, 1876, and continued until the day of opening. The entire management of the transportation of materials and delivery on the floor of the building were confided to Captain Rodgers, to whose entire efficiency is due the fact that not an accident or delay occurred in the delivery of materials properly consigned to him, and to whom is due in great part the promptness with which the Government building was enabled to be formally opened on the great opening day. His efforts have been of the greatest benefit to the Board, and the system so successfully introduced and carried out by him has resulted in great savings of the various appropriations.

It was found in the fall of 1875 that the amounts appropriated for the purposes of the Exhibition were inadequate to the matter in hand, and the funds of the Board were accordingly augmented by the following appropriations in the "act making appropriations to supply deficiencies in the appropriations for the fiscal year ending June 30, 1876, and for prior years, and for other purposes," approved May 1, 1876, viz:

For the purpose of paying the expenses of transportation, care, and custody, arranging and exhibiting, and safe return of articles belonging to the United States to be presented and exhibited in the United States building at the Centennial Exhibition at Philadelphia, during the year 1876, in pursuance of an act of Congress approved March 3, 1875, the following sums are hereby appropriated, namely: For the Interior Department, fifteen thousand dollars; for the War Department, eighteen thousand five hundred dollars; for the Smithsonian Institution, twenty-one thousand dollars; for the United States Commission of Food Fishes, five thousand dollars; for the Treasury Department, fourteen thousand dollars; the same to be disbursed by the Board on behalf of the United States Executive Departments, appointed in pursuance of the order of the President of January 23, 1874: *Provided*, That for contingent expenses any surplus arising from appropriations made to either of said Departments by act of March 3, 1875, is hereby authorized to be used for the purposes herein mentioned.

The details of the participation of the several Departments (excepting the Interior Department, the Smithsonian Institution, and the Commission of Food Fishes) are set forth in the various reports and catalogues herewith transmitted.*

In pursuance of the recommendation of the chairman, the Secretary of War, in May, 1876, authorized the detail of a company of artillery for the protection of the public property of the Government at the Exhibition, and Battery M, Third United States Artillery, consisting of forty-eight men, commanded by Capt. E. R. Warner, was accordingly ordered to report to the chairman for duty in the Exhibition grounds. The thanks of the Board have been tendered to this command for the good and efficient services rendered in guarding the Government property at the Exhibition, and in otherwise advancing the interests of the governmental participation.

Between the members and the attachés of this Board and the president and other officers and members of the United States Centennial Commission, the president and other officers and members of the Centennial board of finance and the director-general and his assistants, the utmost cordiality and harmony prevailed throughout the Exhibition; and this opportunity is availed of for placing on record the acknowledgments of this Board for the generous assistance and the many acts of personal kindness of which they were the recipients at the hands of the entire Exhibition authorities.

The great Exhibition was formally closed on November 10, 1876, and the work of removal of the Government articles was immediately begun. On the 17th of November, however, all packing and work of breaking up the collection in the building were stopped, and only such articles as were immediately needed by the Departments here, and such as were liable to damage by remaining in the building, were authorized to be removed. The reasons for this stoppage were communicated to Congress at the beginning of the present session, in the annual message of the President. As the expense of maintaining the articles at the Government building in Philadelphia until Congress could be able to act on the proposition of establishing a National Museum in this city for their reception was found to be greater than the remnants of the appropriations of the Board would bear, they were, on 18th ultimo, ordered to be transported to Washington, and be there stored to await the action of Congress. They are now arriving, and are placed in such depositories as can be found available for the purpose.

All the buildings erected on the Exhibition grounds by the Government have been sold, as required by law. The main building will be delivered to the purchaser on March 1, 1877. The grounds assigned by the Centennial Commission to the uses of the Government will be sur-

* The representatives of the Interior Department, the Smithsonian Institution, and Commission of Food Fishes, respectively, rendered no report to the Board of their participation in the Exhibition.

rendered as soon as the building has been removed, and all further connection with the Exhibition at Philadelphia will then be at an end.

In conclusion, I beg to submit the conviction that the display made by our Government at the Exhibition has had the most beneficial effect in vindicating our claims upon the respect of the nations of the world. Many objects that were shown in the governmental display, and much of the information that was disseminated, would be of intense interest to the great body of people of other countries whose means did not permit them to incur the expense of a journey to our shores. The great national advantages that will accrue from placing the practical exhibits which demonstrate more particularly our material wealth and resources and the beneficence of our free institutions under the observation of the people of Europe who will assemble at the International Exhibition at Paris in 1878, impels me to the recommendation that a suitable appropriation may be requested of Congress with the view that the governmental display may be so far reproduced at the Paris Exhibition as the changed condition of circumstances and the exigencies of the case may require.

Very respectfully, your obedient servant,

S. C. LYFORD,
Bvt. Lieut. Col. U. S. A.,
Chairman of Board.

SPECIFICATIONS.

JAMES H. WINDRIM, *Architect, Philadelphia, Pa.*

The location of the building is defined upon survey map of Fairmount Park, Philadelphia, and the construction illustrated by the following sheet-drawings: *

No. 1. Ground plan.
No. 2. Longitudinal section.
No. 3. Transverse section.
No. 4. Elevation front.
No. 5. Elevation flank.
No. 6. Elevation rear.

These specifications are intended to embrace the entire work completely finished in every detail as a building and ready for occupancy.

AREA.

	Square feet.
420 by 180′	75,600
180′ by 20′ by 2 times	7,200
100′ by 60′ by 3 times	18,000
8′6″ by 60′ by 4 times	2,040
Total	102,840

The building will consist of a central nave and aisles 100 feet in width by 480 feet in depth, with a cross transept 100 feet in width by 340 feet in depth; attached aisle sections 60 feet by 60 feet, 40 feet by 260 feet, and 20 feet by 20 feet on each side of the center, with office section upon the ends of the nave and transepts, making a total floor area of 102,840 square feet.

EXCAVATIONS, GRADING, AND DRAINAGE.

The entire area inclosed by building to be graded to a level, filled, and solidly rammed, to receive the the floor strings. Grades are noted upon survey sheet.

Foundation trenches for walls and for piers will be excavated to solid bearings and level; those for the exterior walls 3 feet 6 inches below surface grade. The surplus earth resulting from excavations to be

* Drawings of ground plan and of front and flank elevations only are published herewith.

graded or deposited upon premises within 500 feet from the building site as directed.

The drainage by terra cotta pipes is noted by dotted lines upon plan, in courses and sizes figured, to be of an approved quality sound pipes set upon a solid bottom bed, the joints to be made with fresh cement mortar and wiped; connections to be by regular branch bells.

STONE MASON.

The foundations for walls and piers, as defined in position and dimensions by the plans and sections, will be built of a solid quarry building stone, in sizes suitable to build the strongest walls of their respective thicknesses, stones to be laid upon their natural beds, well bonded and bedded in mortar made of sharp grit screened gravel, and fresh lime; inside surfaces of walls to be smoothly dashed and the exposed surfaces upon the outside lines above grade to be finished with joint pointing with cement. The outer walls to be leveled up for timber sill plates; the piers for interior posts to be capped with stone 2 feet by 2 feet, by 7 inches thick, with center dowel-hole in each. Door sills to be 8 to 10 inches thick, in widths to suit construction. Pier caps and sills to be of Port Deposit stone, axed finish.

LUMBER AND CARPENTER WORK.

The entire superstructure will be of timber, all the exposed exterior surfaces to be planed for painting.

The general construction, as sills, posts, braces, cap plates, rafters, &c., to be of sound white pine scantlings, free from wind shakes and large or injurious knots, and in every way a suitable building material for the construction. The roof purlins and general studding to be hemlock. These timbers left from the saw.

The sizes, quantities of the scantling, and their framings are represented by the drawings.

The entire roof areas will be sheathed with narrow pine boards. Gutter to be formed in runs to conductors represented, the base of conductors upon interior lines to be cases 6 feet high above floor level.

The exterior casings to be of white pine, planed, free from shakes large or loose knots. The panel facings upon the exterior of fronts to be framed from 2-inch plank, and secured upon the siding. The cornices and moulding lines to be of white pine lumber, and the crestings cut from plank.

The flooring throughout to be 1½-inch hard pine plank, tongue and groove jointed, in widths laid not over 6 inches, upon 3-inch by 8-inch sound hemlock sets 2 feet apart, and solidly filled between, level with their tops with earth.

Sashes to be made 1¾ inches thick throughout, of white pine, the lantern and transom sections noted, to be hung on pivots to open and close

by lever arms, connecting rod, pullies, and cord, controlling 60 feet lengths each. All permanent sashes to be secured in place by screws.

The entrance doors to be framed from 2-inch plank, lined on the inside, to slide on top by sheaves to rail, or to be hung on hinges as selected.

The general detail of the central sections of the fronts, the entrance doors, &c., to accord with the elevations.

Office sections will be formed by sash partitions, 8 feet 6 inches high, in positions noted, with cornice capping.

Dressing rooms will be fitted up in water-closet furniture, &c., in apartments represented, the divisions to be of worked boarding, the seats of pine plank, with pine risers.

The entire carpenter work to be performed as necessary to complete the building in all its parts as a finished structure, in the most substantial workmanlike manner, with materials of the several kinds approved for the uses to which they shall be applied.

The work to conform in every respect to the plans and to detail drawings which shall be furnished in further exemplification of them.

HARDWARE.

The lantern and transom sections of sashes will be provided with pivots and lever-arm, rod, pulley and cord fastenings controlling sixty (60) feet lengths.

Other movable sashes hang on tight joint butts at bottom, control by top hook fastenings, pullies and cords. Outer doors, to slide, hang on six (6) inch sheaves to top rail, if hung to swing, provided with six (6) inch tight joint hinges, three to a door, and fasten with approved lock with master key to series.

All minor doors to apartments, provided with three-tumbler mortice locks, with master key and with mineral furniture, with hinges and locks in sizes suitable to doors. Water-closet doors provided with rod springs, pulls, and bolts.

Every matter of hardware necessary for the security of the building in construction, and for convenience as furniture to be placed in the work, of the best American manufacture.

IRON WORK.

Dowel pins 1¼ inch diameter will be furnished for all posts of the central construction of the building—bearing upon piers.

Tension members of the roof trusses (60 feet span), and struts are to be of wrought iron, the rafters being wood; foot of rafter will be connected with post bearing by shoes and cast-iron knee brackets with additional rod to counteract wind strain. Two panels from each end of the building, provide with 1 inch diagonal rods denoted, with sleeve nuts for their adjustment.

The aisle roof provide with tie rods and cast-iron brackets rests and their bolt fastenings.

The lantern or dome section provide with cast collar for flag pole with shoe bearings for rafters.

Strap iron for plate connections with posts provide for each joint on the outer bays of the frame work.

This entire iron work to be formed with first quality bar and round iron; cast-iron work to be clean and sharp castings.

ROOFING.

The entire roofs to be covered with granulated slag roofing, as per sample. The roof to be guaranteed free from leak for one year and warranted not to run by sun exposure. In finish, its top cover to be gray color.

Large eave boxes for conductor connections will be formed in position represented by plan; conductors to have soldered joints and be connected with terra-cotta drains at surface grade and protected on top by strainers; all necessary flushings and materials to insure a thoroughly water-tight roof covering to be placed on the building in a skilful, workmanlike manner, and guaranteed for one year free from leak.

PLUMBING.

Water will be supplied to the building by mains, denoted in courses and sizes by dotted lines upon the ground plan, with the fire-plug stations noted.

Pipe to be cast-iron street pressure mains, with the necessary bends, branches, tees, &c., stop valves on each branch, and screw nozzle stop-cocks for hose attachment at each plug station.

WATER-CLOSETS.

Water-closets will be located in position denoted by plans, each provided with four (4) inch traps, china bowl with container, furnished with bronzed cup and handle.

Those in offices to be lined with lead beneath seat for service as urinals.

URINALS.

Gentlemen's apartments to be furnished with (8) Jennings' personal urinals provided with supply and the waste led to well.

WASH BASINS.

Provide with marble top sides and ends will be in position denoted by plans. To have china basins fourteen (14) inches with nickel-plated cocks, plugs, &c., waste to be connected with general drainage.

All supply pipe to be of iron, and all stops, draw-cocks, traps, &c.,

necessary for completely furnishing and placing in ready control the entire plumbing of the building to be performed with approved materials and in the best manner.

GAS.

Gas will be introduced in pipes of capacity per city regulations, for the supply of burners distributed as follows: Through center nave and transept, one outlet each forty (40) feet, two lights each; with proportionate distribution of outlets in other sections; offices and dressing rooms provide with side outlets.

The ends of each line of mains to be led to the outside of the building to supply lanterns. The entire pipe runs to be regulated to drip condense to mains, and the work to pass inspection of the officers of the City Gas Company.

PAINTING AND GLAZING.

All the exterior faces of the building will be painted two coats of best white lead finished in tints selected; the sheathing and ceil finish and general interior surfaces throughout the building to be lime or color washed of approved tints.

Glass throughout to be second quality American; the sizes of lights are figured upon plans and are uniform in the respective sections of the building; the glass to be bedded, securely bradded, and back puttied, left clean and perfect at the completion of the building.

PLASTERING.

The interior and exterior facing of the building to a string board and capping, 10 feet in height above the floor will be plastered two coat work. First coat to be clean sharp bar sand and fresh lime mortar, with proper admixture of fresh slaughtered long hair. Second coat of fresh lime and washed sand, put on and before setting floated to a uniform surface. The work to be guaranteed against scaling off and blistering.

GENERAL CONDITIONS.

The contractor is to provide all materials, carriage, labor, machines, tackle, scaffolding, etc., etc., and every other thing requisite for the full completion of the building, in accordance with the plans and specifications, whether expressed or implied, and all materials and workmanship necessary for the proper construction of the building, or deemed by the supervisor of construction essential to carry out the plans, even though not mentioned, must be provided and placed in the works by the contractor.

The care of the building, and whatsoever belongs thereto, shall be with the contractor until the same is accepted by the building committee of the Board on behalf of the United States Executive Departments. And the works during their progress, and until completion, shall be

subject to the direction and approval in every particular of the said building committee of the board and the supervisor of construction.

The contractor shall be responsible for and bear all loss from accidents of every kind, and all loss or damage which may occur to any person or persons, by or on account of the works upon the aforesaid building.

At the completion of the work the contractor shall remove all rubbish and leave the building completed in every detail for occupancy.

REPORT

ON THE

PARTICIPATION OF THE WAR DEPARTMENT

IN THE

INTERNATIONAL EXHIBITION,

HELD AT

PHILADELPHIA, PA., 1876,

UNDER THE ADMINISTRATIONS OF HON. W. W. BELKNAP, HON. ALPHONSO TAFT, AND HON. J. DONALD CAMERON, SECRETARIES OF WAR.

By MAJOR S. C. LYFORD, Ordnance Department,

BVT. LT. COL., U. S. A.,

Representative of War Department at the Exhibition, and Chairman of the Board on behalf of U. S. Executive Departments.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1884.

WAR DEPARTMENT-PARTICIPATION.

OFFICE OF REPRESENTATIVE OF THE WAR DEPARTMENT,
Washington, D. C., January 2, 1877.

The honorable the SECRETARY OF WAR:

SIR: I have the honor to submit herewith a brief sketch of the organization of the War Department as an Executive Department of the Government, accompanied by illustrated and descriptive catalogues of the articles contributed by the several bureaus of the Department at the International Exhibition of 1876. Appended to these catalogues are special reports upon the military materials displayed at the Exhibition by our own and foreign Governments and by private individuals, prepared by the officers having charge of these several bureau collections.

The participation of the Executive Departments of the Government in the Exhibition had its origin in the reference, in May, 1873, by the Centennial committee on classification, of advance copies of their preliminary sketch of classification of objects to various governmental officials in Washington for critical examination and suggestion. These advance copies were sent to the chiefs of the several bureaus of the War Department, who each made such remarks as were deemed appropriate in that connection. The Chief of Ordnance, General A. B. Dyer, was at the time confined to his bed by sickness, and his military assistant, Maj. S. V. Benét (now brigadier-general and Chief of Ordnance), was absent on leave, leaving myself temporarily in charge of the Ordnance Office. With their approbation and concurrence a reply was forwarded suggesting a separate and distinct display to be made of the war materials of the nation. The substance of this reply met with the hearty concurrence of the Centennial authorities, who transmitted it, in the November following, to the President of the United States, with the replies received from the other bureaus, and strongly urged upon the President the propriety of making not only a display by the War Department, but a collective exhibition of all the Executive Departments. The proposition of the Centennial authorities received the warm approval of the Secretary of War, Hon. W. W. Belknap, to whom the matter was referred, and who subsequently accorded the utmost facilities of his Department for the undertaking. The proposition being favorably considered in Cabinet, an Executive order was issued on January 23, 1874, directing the appointment of a Board on behalf of the several Departments and the Smithsonian Institution, to

prepare, arrange, and display the articles and materials pertaining to each. The Secretary of War did me the honor to appoint me to represent the War Department in the Board, and the President designated me as chairman.

The necessary appropriations for the realization of the plan having been made March 3, 1875, the working out of details was committed by the several members of the Board to subordinate officers selected from their respective Departments. In my own case, I left these details to the care of officers selected by the several chiefs of bureaus of the War Department, to be wrought out under the direction and control of these chiefs, believing, as I did, that by this arrangement the substantial interests of each contributing bureau would be thereby best subserved, and the exhibition of the Department as a whole be rendered more complete and creditable. The wisdom of this plan has been amply attested by the results achieved. The interest of the War Department display was materially enhanced by the efficient services performed by the officers in charge of the several bureau collections, whose emulation, energy, and intelligence entitle them to special mention.

The display by the Quartermaster's Department was prepared, under the direction of the Quartermaster-General, by Capt. John F. Rodgers, Quartermaster's Department, whose thorough and efficient administration of the affairs of his section reflected great credit on his branch of service. The observations of this officer show that most of the foreign mechanical devices appropriate to his department on show had nothing to commend them on the score of superiority over our own domestic productions; and, in many instances, the marked superiority of American products is directly attested by him.

The display by the Medical Department was prepared under the direction of the Surgeon-General by Assistant Surgeon (now Surgeon) J. J. Woodward, Medical Department, whose high professional standing is an earnest of the exceeding interest and value of the display made by him. The medical exhibit was designed to represent as fully as possible the methods and appliances employed by the Medical Corps in the discharge of their duties. Four classes of objects were represented either by the objects themselves, by models, or by photographs, viz: I. Hospitals; II. Devices for the transportation of the sick and wounded; III. Medical and hospital supplies, including surgical instruments and prothetic apparatus; IV. Methods employed for the systematic study of the diseases and injuries of soldiers, with a view to their more effectual treatment.

Surgeon Woodward reports that the appliances and methods of the medical service of other armies than our own were very incompletely represented at the Exhibition. He regrets that it was not found practicable to extend special invitations to the army medical departments of other governments, as was suggested by the Surgeon-General of the Army in a letter to the honorable the Secretary of War, dated May 5,

1874, and indicates the advantages which would probably have resulted if this suggestion could have been realized. Notwithstanding the absence of such special invitations, however, the Swedish, Russian, Spanish, and Japanese Governments each exhibited a few objects of interest in connection with the transportation and management of the wounded, and objects illustrative of the same and allied subjects were displayed by various private individuals and societies, especially in the exhibit of the Netherlands and Germany. The latter was by far the most extensive collection of the kind in any foreign department of the Exhibition. A sketch of these exhibits will be found in the accompanying report of Surgeon Woodward, to which is appended a report by Assistant Surgeon G. A. Otis, Medical Department, in which the appliances relating to the transportation and surgical care of wounded are more particularly discussed.

Surgeon Woodward was assisted by Acting Assistant Surgeon H. C. Yarrow at the post hospital, erected contiguous to the Government building as an exhibit of the Medical Department. This latter officer acted as attending physician to the enlisted men and employés about the building, and great credit is due him for the zeal and professional ability with which the duties devolving on him were discharged.

A large number of foreign and American medical men visited the Exhibition, the number registered at the hospital being over 7,500. The International Medical Congress which held its sessions at the University of Pennsylvania during the month of September was largely attended, and was one of the most interesting of the many medical events of the summer.

The display by the Engineer Department was prepared under the direction of the Chief of Engineers by Capt. D. P. Heap, Corps of Engineers, who efficiently managed the affairs connected with that department. He was assisted during a considerable period of the Exhibition by Lieut. S. S. Leach, Corps of Engineers, who is entitled to favorable mention. The report on civil engineering, prepared by Captain Heap, and the report on military engineering, prepared by Capt. James C. Post, Corps of Engineers, and also a report on cements, artificial stones, &c., prepared by Lieut. Col. Q. A. Gillmore, Corps of Engineers, are appended, and will be found of much value in connection with engineering subjects.

The display by the Ordnance Department was prepared under the direction of the Chief of Ordnance by First Lieut. Henry Metcalfe, Ordnance Department, assisted by First Lieut. C. W. Whipple, Ordnance Department. Great credit is due to Lieutenant Metcalfe for the able and efficient manner in which the variety of duties devolving on him were discharged, as well as to Lieutenant Whipple for the valuable assistance rendered to him in connection therewith.

In the enginery of war, particularly in that part which pertains directly to the Ordnance Department, it is to be regretted that induce-

ments were not extended to foreign Governments and to private manufacturers in European States to exhibit the products of their ingenuity and skill in the construction of missile weapons with the appliances for their use. Could such exhibits have been made it cannot be doubted that as great benefits would have accrued in the future to our own service as now is confidently expected in other branches of mechanical industry. Some few nations and manufacturing establishments showed samples of a portion of their artillery and small-arms; but it should not be concluded that what was shown exhibited the war capacity of any one of these countries.

I ask the perusal of the admirable descriptions of the best in the different classes of ordnance stores and machinery by Lieutenant Metcalfe, which form an exceedingly interesting part of this volume. This officer, and his assistant, Lieutenant Whipple, have been assiduous in collecting and arranging such data as may be of use to the Ordnance Department, and the matter gathered has been arranged in the following classification, viz: *A.* Cannon and carriages; *B.* Cannon ammunition; *C.* Small-arms; *D.* Small-arm ammunition; *E.* Equipments, leather-work, &c.; *F.* Machinery; *G.* Instruments; *H.* Miscellaneous.

It will be found that in describing and illustrating machinery a very judicious selection has been made from the large number of power-producing, power-transmitting, and power-applying mechanisms on exhibition; and, while many of the devices are new to the general reader they have nearly all been sufficiently tested to demonstrate their usefulness in saving cost, labor, and time in their products.

In artillery, heavy guns, and projectiles the copious reference to the works of Messrs. Krupp, of Essen, and others will give a most extended knowledge of the capacity of famous foreign establishments, and perhaps awaken such an interest in the minds of our people relative to the great problem of national defense and safety as will again place this country foremost in the production of heavy guns, and by inducing a fostering care of our iron-working industries, enable us in the future to be in a position to repel an attack on our seacoast by a first-class European power.

In small-arms, rifles, and pistols and their ammunition Lieutenant Metcalfe's gleanings show little of value not before well known in this country, but serve to demonstrate that the United States is not behind hand in inventive genius in this most important branch, if, indeed, she does not lead the world in her capacity to produce the best of all breech-loading arms using metallic ammunition; and it should be a matter for serious consideration why, when occupying such a proud place in the production of arms for infantry and cavalry, she has so far fallen behind in the equally important arm, the heavy artillery, especially when it is well known that nearly everything good in heavy guns, powder, and projectiles was invented in the United States, but for lack of appropri-

ations by Congress, and from national apathy, has been developed abroad.

Machine guns, using infantry ammunition, like small arms, have attained a high degree of excellence, and, outside of American invention and manufacture, there are no systems exhibited worthy of mention.

In the ordnance display at the Government building a great attraction was the metallic-cartridge machinery in full operation, producing the finished copper case ready for priming and filling for actual use. This machinery, and that also in operation for making the service rifle, must have been new to most of the visitors, and could not have failed to attract notice by the precision and automatic movements of its delicate mechanism. The cartridge machinery was taken from daily use at the Frankford Arsenal, and the rifle machinery from the National Armory, skilled operatives, men and women, having been brought from either place. I think I am but doing justice to the officers in charge of the ordnance exhibit, and no injustice to my colleagues, the representatives of the other Executive Departments, to say that in the building, each day densely thronged, no place seemed to arrest more the attention of the people, nor to hold them longer in contemplation, than that occupied by this machinery.

A most interesting collection of small arms—over 100 in number—illustrated the progressive development in manufacture, from the hand-made arm of Revolutionary times, with its smooth bore and rough, home-made, paper-cartridge of inferior powder, to the present handsome machine-made rifle, with its beautifully finished metallic ammunition. And it must be remembered that the great advance in these weapons is due to the inventive genius of the American people and the great opportunities that have been afforded by the Government armories, their well arranged machinery and appliances, and the knowledge and skill of the officers and experts of the Ordnance Department for bringing to success the many devices offered; and in this connection, the methods used to determine the force and other phenomena of powder and projectiles, as displayed in the laboratory adjacent to the Government building, the chronoscopes and other ballistic machinery, added but another evidence of the care used in the manufacture of these weapons of war.

Lieutenant Metcalfe's report gives a list of the heavy guns, siege and field artillery, their carriages and peculiar projectiles, both service and experimental, exhibited. He especially asks attention to the incidents connected with the removal of the 20-inch Rodman gun, weighing about 116,000 pounds, from Fort Monroe to its position on its carriage in Fairmount Park. With the means and appliances at his command, the successful landing of this mass from the vessel on which it was transported, in such a short period of time, without hitch or accident, must be considered as unparalleled.

I believe that the exhibition of war materials, meager as it was, has shown to every thoughtful mind that the parsimonious expenditures for

preparations for defense of late years have not been in the interests of economy or of dignity and may lead to the belief that should such an apathetic feeling on the part of Congress toward providing the means of defending the honor of the nation continue the time may come when those charged with such provision will not be held guiltless should disaster occur.

If this exhibition should be the means of awakening our people to a sense of our national danger and defenseless condition the display by the Government will not have been in vain. It is useless to attempt to conceal the fact from foreigners that against their fleets we have nothing to offer worthy of the name, and it is criminal to allow our own people to remain in ignorance of our condition. If an emergency should come—and wars now-a-days come suddenly—unquestionably the blame for our defenseless condition will be placed where it belongs; but the losses and disgrace will hardly be mitigated by the reflection that had the advice of the authorities been listened to, and proper means provided by Congress, the result might have been different.

Ten years ago there was hardly a nation better prepared to repel an iron-clad fleet attack on her great commercial cities by her seaboard; at present, there is scarcely one which would be compelled to offer such feeble resistance. All other nations have progressed by judicious expenditures of national means; we, in fancied security, have stood still and allowed them to appropriate to themselves our inventions and our mechanical ingenuity, and, to-day, abounding in wealth and resources of all kinds, we offer ourselves a willing sacrifice to any feeble power that may wish to enforce an unreasonable demand.

The display by the Signal Service was prepared, under the direction of the Chief Signal Officer, by First Lieut. F. C. Grugan, Second United States Cavalry, Acting Signal Officer, who creditably presented this branch of the public service. The report of Lieutenant Grugan gives a condensed history of the formation of the United States Signal Service, followed by an exposition of its workings. The signal apparatus exhibited by some of the foreign governments are described, and several recommendations are made for the improvement of our own service in minor particulars. He closes his report with a description of the successful transmission by telegraph, and publication in the daily New York Herald, of the weather maps issued by the central office in Washington, D. C.

The several reports on professional subjects made by these officers and appended to the catalogues of their respective sections, evince with what diligence they must have labored, amidst the excitements and allurements of the occasion, to seek out and secure for the benefit of the public service the best fruits of the Exhibition in all things relating to their several special branches of service.

The Corps of Cadets from the United States Military Academy at West Point, N. Y., were brought to the Exhibition in the latter part

of June, 1876, and remained in camp within the Exhibition grounds for ten days. The advent of the cadets at the Exhibition afforded an opportunity to the people of the country to witness the thoroughness of discipline of this admirable institution, and was of great practical advantage to the cadets in an educational point of view.

For the protection of the public property of the various War Department bureaus represented at the Exhibition, and to afford the necessary assistance to and attendance upon the officers in charge, 40 enlisted men were detailed for duty at the Government building, as follows: Hospital stewards, 8; enlisted men of Engineers, 8; of Ordnance, 16; of Signal Service, 8. In addition, Battery M, Third United States Artillery, composed of 48 men, commanded by Capt. E. R. Warner and Lieut. B. H. Randolph, were encamped within the grounds throughout the whole Exhibition, and rendered efficient service in connection with the governmental participation.

It is seriously to be regretted that a more general display of war materials was not made by the great foreign military powers. The display of our own Government stood pre-eminent for its variety and completeness, and the comparisons thereby afforded will, if properly understood, exert a beneficial effect on the military spirit of our people, by inspiring a patriotic desire to retain in the van of national greatness the creditable position to which our benign institutions, our wealth, and our natural resources entitle us. The encouragement of this impulse is within the legitimate functions of Government, and such measures as may have the effect of generating and promoting this spirit should meet the hearty approval of all lovers of their country. The beneficial effects to result from a comparison of our war materials in other lands, where greater opportunities and facilities for more general and thorough comparisons may reasonably be expected, leads me to recommend strongly to the attention of the authorities the advisability of directing that full representations of these materials be forwarded to the next International Exhibition, which takes place at Paris, France, in 1878, and that the necessary appropriation be asked therefor.

In conclusion, I would respectfully recommend that, if approved by you, the papers which I have the honor herewith to submit may be transmitted to the Board on behalf of the United States Executive Departments, for incorporation into its general report on the Exhibition designed to be submitted to Congress for publication.

Very respectfully, your obedient servant,

S. C. LYFORD,

Bvt. Lieut. Col., U. S. A.,

Representative of War Dept. at International Exhibition, 1876.

[Indorsement.]

This interesting summary of the operations of the War Department representative at the Centennial Exhibition is, with its accompanying documents, respectfully referred to the Board on behalf of the Executive Departments, in anticipation that they will be presented to Congress for publication.

Colonel Lyford's views as to the participation of the War Department at the Paris Exhibition in 1878 meet my hearty approval, and will be forwarded to the extent of my ability.

J. D. CAMERON,
Secretary of War.

WAR DEPARTMENT, *January* 3, 1877.

International Exhibition, 1876.

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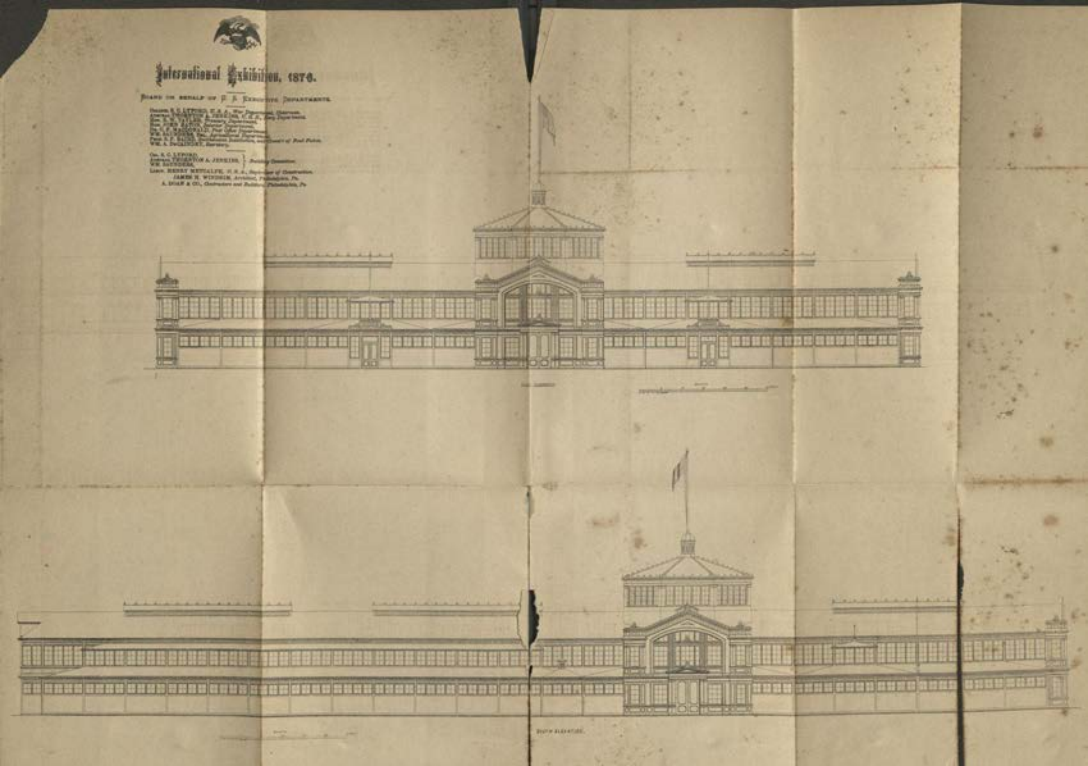

THE ESTABLISHMENT

OF THE

WAR DEPARTMENT

AS ONE OF THE

CIVIL EXECUTIVE DEPARTMENTS OF THE U. S. GOVERNMENT;

WITH A GENERAL VIEW OF ITS

INTERIOR ORGANIZATION AND ADMINISTRATION.

BY

WILLIAM A. DE CAINDRY,

Secretary of the Board on behalf of U. S. Executive Departments at International Exhibition, 1876.

THE WAR DEPARTMENT.

THE ADMINISTRATION OF THE WAR OFFICE DURING THE REVOLUTION.

On June 12, 1776, the Continental Congress took up for consideration the report made by a committee that had been appointed to consider the expediency of establishing a War Office, when the following resolution[1] was passed:

Resolved, That a "Committee of Congress" be appointed by the name of the "Board of War and Ordnance," to consist of five members.

That a Secretary and one or more clerks be appointed by Congress, with competent salaries, to assist the said Board in executing the business of their Department.

That it be the duty of the said Board to obtain and keep an alphabetical and accurate register of the names of all officers of the land forces in the service of the United Colonies, with their rank and the dates of their respective commissions; and also regular accounts of the state and disposition of the troops in the respective colonies; for which purpose the generals and officers commanding in the different departments and posts are to cause regular returns to be made in the said War Office.

That they shall obtain and keep exact accounts of all the artillery, arms, ammunition, and warlike stores belonging to the United Colonies, and of the manner in which, and the places where, the same shall, from time to time, be lodged and employed, and that they shall have the immediate care of all such artillery, arms, ammunition, and warlike stores as shall not be employed in actual service; for preserving whereof they shall have power to hire proper magazines at the public expense.

That they shall have the care of forwarding all dispatches from Congress to the colonies and armies, and all moneys to be transmitted for the public service by order of Congress; and of providing suitable escorts and guards for the safe conveyance of such dispatches and moneys, when it shall appear to them to be necessary.

That they shall superintend the raising, fitting out, and dispatching all such land forces as may be ordered for the service of the United Colonies.

That they shall have the care and direction of all prisoners of war, agreeable to the orders and regulations of Congress.

That they shall keep and preserve in the said office, in regular order, all original letters and papers which shall come into the said office by order of Congress, or otherwise, and shall also cause all draughts of letters and dispatches to be made or transcribed in books to be set apart for that purpose, and shall cause fair entries in like manner to be made, and registers preserved of all other business which shall be transacted in the said office.

That before the Secretary, or any clerk of the War Office, shall enter on his office they shall respectively take and subscribe the following oath, a certificate whereof shall be filed in the said office: "I, A. B., do solemnly swear that I will not directly or indirectly divulge any matter or thing which shall come to my knowledge as Secretary of the Board of War and Ordnance (or clerk of the Board of War and Ordnance) established by Congress, without the leave of the said Board of War and Ord-

[1] Journals of Congress (Way & Gideon's ed., 1823), vol. 1, p. 370.

nance; and that I will faithfully execute my said office according to the best of my skill and judgment. So help me God."

That the said Board of War be authorized to hire suitable apartments, and provide books, papers, and other necessaries at the Continental expense, for carrying on the business of the said office.

On the following day five members of the Congress were chosen to constitute the Board, and Richard Peters, esq., was elected Secretary of the Board.[1] A salary of $800 a year was attached to this latter office.[2] On July 8 the Congress directed the commanding officer of the local military at Philadelphia "not to order Captain Peters out of the city, as his service and attendance is necessary in the War Office."[3] This office, at that date, was located on Market street, near Fourth, in the city of Philadelphia.[4] On 18th of July a sixth member was added to the Board.[5]

Congress had already provided for the supreme military command of the Continental army, by the appointment of George Washington as "General and Commander-in-Chief," with full power and authority to act as he should think fit for the good and welfare of the service, subject to the rules and discipline of war as transmitted to him, and to such orders and directions as he should receive from Congress or a committee thereof,[6] and the Congress had pledged their lives and fortunes to maintain and assist him and to adhere to him as such. They had also provided for an Adjutant-General, a Quartermaster-General, a Commissary-General, a Paymaster-General, a Mustermaster-General, and other necessary staff officers for the general administration of military matters in the main army, and had required of them to render stated reports and returns to Congress.[7] In addition, they had provided deputies in these various branches for each separate army, and enjoined on them also the duty of making reports and returns of their actions to Congress.[8] Moneys for the payment of the troops, and for defraying the local expenses of active operations were voted in bulk for the Paymaster-General;[9] and he, with the Deputy Paymaster-General, was required to "make monthly returns to Congress of their expenditures, and the state of the military chests in their several departments."[10] The Commissary-General, Quartermaster-General, Deputy Commissary, and Deputy Quartermasters-General, were required to make returns monthly, at least, of the stores under their direction, and the distribution of them.[11]

Concerning the institution of the War Office, the President of Congress wrote General Washington,[12] on June 14, 1776, as follows:

The establishing a War Office is a new and great event in the history of America and will doubtless be attended with peculiar advantages, when properly conducted

[1] Jour. Cong., vol., 1 p. 372.
[2] Ibid., p. 372.
[3] Ibid., p. 401.
[4] Am. Arch., 5th series, vol. I, p. 34.
[5] Jour. Cong., vol. 1, p. 416.
[6] Ibid., p. 85.
[7] Ibid., pp. 84, 365, 431.
[8] Ibid., pp. 365, 431.
[9] Ibid., pp. 134, 147, 175.
[10] Ibid., pp. 365, 431.
[11] Ibid., p. 431.
[12] Am. Arch., 4th series, vol. VI, p. 884

and inspected. I hope the committee will be ready in a few days to enter upon the execution of their duty. You will see the outlines of this office in the inclosed resolves. Some further regulations, it is more than probable, will be necessary in the course of time. The Congress have only laid a foundation at present; it still remains, in a great measure, to erect a system of rules and laws that will enable us to carry on military operations with more knowledge, certainty, and dispatch.

To which General Washington replied[1] from New York, June 20, 1776:

The instituting a War Office is certainly an event of great importance, and in all probability will be recorded as such in the historic page. The benefits derived from it, I flatter myself, will be considerable, though the plan upon which it is founded may not be entirely perfect. This, like other great works, in its first edition, may not be free from error. Time will discover its defects and experience suggest the remedy, and such further improvements as may be necessary. But it was right to give it a beginning, in my opinion.

The Board of War and Ordnance became at once the channel for the transaction of a great mass of business in connection with military operations, and in its capacity as a committee of Congress was an advisory board to Congress on all subjects relating to military matters.[2] Mail matter to and from the Board was carried free in the mails;[3] and in all examinations before it it was authorized to administer oaths.[4]

On June 17, 1777, a deputy secretary to the Board of War was appointed,[5] and on July 18, 1777, Congress resolved to give the Board a new organization by declaring "that three gentlemen, not members of Congress, shall be appointed to conduct the business of the Board of War, under the direction of the present Board."[6] This intention was carried out on October 17, 1777,[7] by the passage of the following resolution, the Congress in the mean time having been compelled to evacuate the city of Philadelphia on account of the approach of the enemy, whence they proceeded to Lancaster, and thence to York, Pa.[8]

Resolved, That a Board of War be established to consist of three persons not members of Congress.

That there shall be a Secretary to the said Board, to be appointed by Congress.

That the Board shall recommend for the approbation and appointment of Congress as many clerks as shall be necessary for assisting them in the execution of the business in their Department.

That the power and duties of the said Board be as follows: To obtain and keep an alphabetical and accurate register of the names of all officers in the land forces in the service of the United States, with their ranks and the dates of their commissions; to fill up all military commissions which shall be signed by the President of Congress and countersigned by the Secretary of the War Office, and to publish annually a register of all appointments; to obtain and keep regular and exact accounts of the numbers and disposition of the forces of the United States; to obtain and keep exact accounts of all the artillery, arms, ammunition, warlike stores, clothing, medicines, and provisions belonging to the United States, and of the manner in which and the places where the same shall from time to time be lodged and employed; to take the immediate care

[1] Am. Arch., 4th series, vol. VI, p. 991.
[2] Jour. Cong., 1776, *passim*.
[3] Ibid., vol. 1, p. 469.
[4] Ibid., p. 556.
[5] Jour. Cong., vol. 2, p. 169.
[6] Ibid., p. 200.
[7] Ibid., p. 295.
[8] Ibid., p. 270.

and direction of all such artillery, arms, ammunition, and warlike stores as shall be employed in actual service; to superintend the building and management of laboratories, arsenals, foundries, magazines, barracks, and other public buildings, the necessity of which they are from time to time to report to Congress; to forward all dispatches from Congress to the States and armies, and all moneys ordered by Congress to be transmitted for the public service, and to provide guards for the safe conveyance of such dispatches and moneys whenever it shall appear to the Board to be necessary; to superintend the raising, recruiting, and dispatching of the land forces in the service of the United States; to take care and direction of prisoners of war; to lay before Congress proper and seasonable estimates of such artillery, arms, ammunition, and warlike stores, clothing and medicines as shall from time to time be wanted for the service of the United States; to execute all such matters as they shall be directed; to give their opinion on all such subjects as shall be referred to them by Congress; and in general to superintend the several branches of the military department; and if at any time they think a measure necessary for the public service, to which their powers are incompetent, they shall communicate the same to Congress for their direction therein; to keep fair entries of all the business transacted by them.

The said Board shall sit in the place where Congress shall be held, and no member of the Board shall absent himself without leave of Congress.

All the proceedings of the Board shall be inspected by Congress, or a committee by them appointed for that purpose, once a month, or oftener, as may be thought proper and convenient; and every member of Congress may have free access to the records of the said Board and take copies thereof, excepting copies of returns of the armies, provisions, or military stores, which shall not be delivered to any member without the order of Congress.

Resolved, That all military and other officers attending upon or connected with the Army of the United States be, and they are hereby, required and enjoined to observe the directions of the said Board in making and transmitting proper returns and such other matters as may tend to facilitate the business of the said Board.

That it be recommended to each of the United States to give the said Board all necessary assistance in the execution of the business of their department.

Resolved, That the salary of each of the three gentlemen who shall conduct the business of the Board of War be $2,000 per annum.

The new Board of War,[1] selected November 7, 1777, under these resolutions, consisted of General Thomas Mifflin, Col. Timothy Pickering, and Col. Robert H. Harrison (the secretary to General Washington), the latter of whom,[2] on November 21, declined the appointment.

On November 22, Congress resolved[3]—

that the former Board of War be authorized to proceed on the business of that Department till such times as a sufficient number of the Commissioners of the War Office shall attend:

and on November 24, the Board reported[4]—

that they have had a conference with General Mifflin on the late establishment made by Congress for conducting the War Department, and are unanimously of opinion that a sufficient number of commissioners have not been appointed for giving due weight to the execution of the regulations which may be recommended by the Board and adopted by Congress, and particularly for enabling one of the Board of Commissioners to visit from time to time the different armies, posts, or garrisons, in order to see that the regulations adopted by Congress are carried into execution, and to examine what are the wants of the Army, and what defects or abuses prevail from time to time in the different departments.

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[1] Jour. Cong., vol. 2, p. 317. [2] Ibid., p. 342. [3] Ibid., p. 345. [4] Ibid., p. 348.

Congress, therefore, upon that day resolved[1]—

That two additional commissioners be appointed to execute the Department of the War Office, in pursuance of the resolution of the 17th of October last, and that any three of the said commissioners have full power to transact business, anything in the former resolutions respecting the Board to the contrary notwithstanding.

On November 27, 1777, Major-General Gates was elected President of the Board of War, and Joseph Trumbull and Richard Peters (Secretary of the old Board) were elected members.[2] Joseph Trumbull being, on account of ill health, unable to attend to his duty at the Board, and being desirous of resigning, his resignation was accepted April 18, 1778.[3] On January 6, 1778, Congress selected Bvt. Brig. Gen. James Wilkinson to be Secretary of the Board of War,[4] and on 31st March, 1778, his resignation of this office was accepted.

Great Britain had, early in the controversy between herself and the colonies in America, prohibited the further importation of arms and ammunition into those colonies, and had endeavored to prevent other nations from affording a supply. As early as July 15, 1775,[5] the Continental Congress had passed the following resolution:

Resolved, That for these better furnishing the colonies with the necessary means of defending their rights, every vessel importing gunpowder, saltpeter, sulphur (provided they bring with the sulphur four times as much saltpeter), brass field pieces, or good muskets fitted with bayonets, within nine months from the date of this resolution, shall be permitted to load and export the produce of these colonies to the value of such powder and stores aforesaid, the non-exportation agreement notwithstanding; and it is recommended to the committees of the several provinces to inspect the military stores so imported, and to estimate a generous price for the same, according to their goodness, and permit the importer of such powder and other military stores aforesaid to export the value thereof, and no more, in produce of any kind.

Again, on July 18, 1775:[6]

That it be recommended to the assemblies or conventions in the respective colonies to provide, as soon as possible, sufficient stores of ammunition for their colonies; also, that they devise proper means for furnishing with arms such effective men as are poor and unable to furnish themselves.

And again, on November 4, 1775:[7]

Resolved, That it be recommended to the several assemblies or conventions of the colonies respectively to set and keep their gunsmiths at work to manufacture good firelocks with bayonets; each firelock to be made with a good bridle-lock, three-quarters of an inch bore, and of good substance at the breech; the barrel to be three feet eight inches in length, the bayonet to be eighteen inches in the blade, with a steel ramrod, the upper loop thereof to be trumpet-mouthed; that the price to be given be fixed by the assembly or convention or committee of safety of each colony, and that until a sufficient quantity of good arms can be manufactured they import as many as are wanted, by all the means in their power.

Resolved, That the good arms of such soldiers as leave the service be retained for the use of the new army, on a valuation made of them.

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[1] Jour. Cong., vol. 2, p. 348.
[2] Ibid., p. 352.
[3] Ibid., p. 517.
[4] Ibid., p. 395, 495.
[5] Jour. Cong., vol. 1, p. 118.
[6] Ibid., p. 119.
[7] Ibid., p. 164.

On January 15, 1776, a Cannon Committee[1] was appointed by Congress, under the following resolution, viz:

Resolved, That a committee of five be appointed to make an estimate of the number of cannon that may be wanted for the defense of the United Colonies, and to devise ways and means for procuring them, and that it be an instruction to said committee to inquire what size cannon can be cast in these colonies.

This committee was, on various subsequent occasions during the war, authorized to contract for the procurement of large quantities of iron and brass ordnance.

A committee similar in character, for promoting the manufacture of muskets and bayonets, was also appointed,[2] and on June 25, 1776, was directed to consider the propriety of granting a bounty, or other means, for encouraging the making of muskets.[3]

The various supply departments of the Army underwent radical changes in organization during the years 1777 to 1779, through Congressional legislation, had at the instance of the Board of War, after consultations with General Washington.

Some of the more material alterations will be here referred to, the language of the various resolutions for the purpose being given entire, in most cases.

On December 13, 1777,[4] the Board of War, to whom was referred certain letters from General Conway, brought in a report, whereupon, after consideration, it was—

Resolved, As the opinion of this Congress, that it is essential to the promotion of discipline in the American Army, and to the reformation of the various abuses which prevail in the different departments, that an appointment be made of Inspectors-General, agreeable to the practice of the best-disciplined European armies.

Resolved, That this appointment be conferred on experienced and vigilant general officers, who are acquainted with whatever relates to the general economy, maneuvers, and discipline of a well-regulated army.

Resolved, That the duties of these officers be as follows: To review, from time to time, the troops, and to see that every officer and soldier be instructed in the exercise and maneuvers which may be established by the Board of War; that the rules of discipline be strictly observed, and that the officers command their soldiers properly, and do them justice.

* * * * * * *

Resolved, That the Inspectors-General shall make these reviews in the beginning and at the latter end of every campaign, and at such other times as the Commander-in-Chief shall direct, or as they themselves shall severally judge proper, or shall receive orders for that purpose from the Board of War, first giving notice thereof to the Commander-in-Chief and obtaining his leave for reviewing the said troops.

* * * * * * *

Resolved, That it be referred to the Commissioners of the War Office [Board of War] to report such further regulations for this office as they shall deem calculated to extend its utility, and to promote the end of its institution.

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[1] Jour. Cong., vol. 1, p. 236.
[2] Ibid., p. 273.
[3] Jour. Cong., vol. 1, p. 386.
[4] Ibid., vol. 2, p. 372.

On February 5, 1778,[1] Congress took into consideration a report of the Board of War, and thereupon—

Resolved, That the following plan be adopted for carrying into immediate execution the important business of the Quartermaster-General:

1st. The military line, to be styled the Quartermaster-General's, which is to include the regulating of marches, encampments, order of battle, &c., as described in the books of the profession; this officer not to have the disposal of public money, except small occasional sums for defraying petty expenses in the Army.

2d. The Commissary of Forage, who is to be confined to that article in his purchases.

3d. The Commissary for Horses and Wagons.

4th. The agents for the purchase of tents, entrenching tools, building of barracks, and for all the smaller supplies of the department.

The three last to be governed in their purchases by the estimates and orders of the Quartermaster-General or the Board of War.

Ordered, That the Board of War prepare suitable regulations for the Quartermaster-General's Department, agreeable to the foregoing plan.

On February 6, 1778,[2] Congress privided, by resolutions, for "the better regulating the hospitals of the United States," and, on February 11,[3] it resumed the consideration of a report of the Board of War on the Department of the Commissary-General of Military Stores, and thereupon—

Resolved, That there shall be one Commissary-General of Military Stores, whose business it shall be to receive and deliver all arms, ammunition, and accouterments of every species and denomination; to provide and contract for all such articles as may be wanted in this Department, according to the direction he shall receive from the Board of War and Ordnance; to receive and collect returns from all the different States where there are any Continental arms and stores; draw them into one general return, and, on the first day of every month, deliver one to the Board of War and Ordnance. In case of vacancy, occasioned by death, resignation, or otherwise, of any of the commissaries, commissaries' deputies, or conductors, which may happen in any department near to where the Commissary-General may be, he shall have permission to fill such vacancy *pro tempore*, until it shall be confirmed or disapproved by Congress.

All moneys to be drawn on account of military stores to be by application of the Commissary-General or his deputies to the Board of War and Ordnance; and all moneys so drawn to be accounted for by him once in every six months to the Board of Treasury, or to such auditors or commissioners as the said Board shall direct. All commissaries, deputy commissaries, or conductors who may have money advanced them by the Commissary-General for the use of their several departments to keep regular accounts, and produce vouchers and receipts for the sums paid, and account for the same to the Commissary-General once every month, or as often as called for.

All Continental armorers shall be under the direction of the Board of War and Ordnance and of the Commissary-General of Military Stores; the armorers to receive from the said commissary all arms to be repaired, make returns of the state of repairs when demanded, and deliver the arms, when repaired, into his store. The principal armorer or armorers of each and every armory to be accountable for all such arms as he or they shall receive, until they are repaired and delivered to the Commissary-General, his deputies, or assistants; and the said Commissary-General shall see that every method

[1] Jour. Cong., vol. 2, p. 432. [2] Ibid., p. 433. [3] Ibid., p. 439.

is taken by the armorers to hasten the repairs of the arms; the principal armorers to receive money from the Commissary-General for the contingent expenses of their departments, and the Commissary-General shall produce their accounts and vouchers at the adjustment of his accounts.

That there be as many deputies, assistants, commissaries, deputy commissaries, conductors, and clerks as the exigency of the service shall require, to be appointed by the Board of War and Ordnance; and the said Board are from time to time to report all such appointments to Congress.

* * * * * * *

That for the future no rank be annexed to the officers in this Department, except they belong to the regiment of artillery artificers, and then their rank only to take place as officers of that corps; the pay also which they receive as officers in that regiment to be included in the pay herein settled for the officers of the Commissary-General's Department.

That a return be made to the Board of War and Ordnance, once every month, of all officers employed in the civil branch of ordnance and military stores.

All commissaries, deputy commissaries, conductors, and clerks who shall have the separate charge of any stores, are, on the first day of every month, to make out an exact return of all cannon and military stores of every species and denomination, one copy whereof they shall transmit to the Commissary-General, who is to put them into one general return, as heretofore directed, and one other copy thereof the said commissaries, deputy commissaries, conductors, and clerks are to send to the Board of War and Ordnance.

All the artillery artificers that are or may be employed at any armories, laboratories, foundries, or military magazines (those employed with the army in the field excepted) shall be under the immediate direction and subject to the orders and command of the Commissary-General, or the officer directed by him to take charge of the same.

The Quartermaster-General, his deputies and assistants, shall give the Commissary-General every assistance of teams for the removal of public stores, and in case there be no quartermaster in the department or place from whence the stores are to be removed the Commissary-General shall have power to procure teams in the way and manner that will best promote the public service.

All officers, artificers, and others in the Ordnance and Military Department shall be governed by the rules and articles of war, in the same manner as other officers in the artillery of the United States.

The Commissary-General shall give such forms or returns and instructions to his deputies, assistant commissaries, conductors, &c., as the service and situation of their department shall require; and all officers in this department are to attend to such orders and instructions as they shall receive from time to time from the Board of War and Ordnance or the Commissary-General.

All regulations incidental to the Department, and not enlarging the powers and authorities here given, shall be settled and made by the Board of War and Ordnance.

The Board of War and Ordnance shall transmit, from time to time, as the service shall render necessary, transcripts of all returns received from the Commissary-General of Military Stores, and also accounts of all ordnance and stores under their care or belonging to the United States, and the places where the same are deposited, to the Commander-in-Chief of the armies of the United States, in order that he may make such requisitions of supplies for the army under his immediate command, or for the separate departments, as he shall think proper, and give such advice and directions as to the disposition of them as circumstances may from time to time require.

The commanding officer of artillery for the time being, in the grand army, with the chief engineer, commissary of artillery, and eldest colonel of artillery in camp, or such of them as are present with the army, shall be a subordinate Board of Ordnance, under the direction of the Commander-in-Chief or the Board of War and Ordnance,

for transacting all business of the Ordnance Department necessary to be done in the field, and to have the care of all ordnance and stores at camp; and in case of sudden exigency the Commissary-General of Military Stores shall be obliged to obey their directions as to any supplies wanted by the army out of the stores not in camp; and the said Board shall correspond with and report their proceedings to the Board of War and Ordnance, from whom they are to receive any necessary assistance.

* * * * * * *

That if the exigency of the service makes it necessary to employ, at any time or place, more artificers than the Commissary may have enlisted or can enlist, then he, his deputies or assistants, may engage them for the time of such necessity on the most reasonable terms possible, with the approbation of the Board of War and Ordnance.

* * * * * * *

Resolved, That the Board of War and Ordnance be empowered to make a contract with Mr. Byers, as superintendent of a foundry of brass cannon.

On February 12, 1778,[1] a report of the Committee on the Treasury, to whom had been referred a letter from the Board of War, was taken into consideration, and it was thereupon—

Resolved, That a proper person be appointed to act as Secretary of Ordnance and Paymaster to the Board of War and Ordnance; that his salary shall be $90 a month.

That the said Paymaster shall answer all warrants drawn on him by the Board of War and Ordnance out of the money which he shall receive by orders of Congress, and shall keep fair accounts of his payments, and make monthly returns thereof to the Board of Treasury; he shall also transmit returns once a month, or oftener, to the Paymaster-General, or other proper officer or officers, of all advances made to Continental troops or militia in actual service, in order that the proper stoppages may be made.

That the Board of War and Ordnance shall from time to time make out the proper estimates of money to be advanced for the use of their Department, and lay the same before Congress, and all moneys granted by Congress on their application shall be applied to the purposes set forth in the said estimate.

On the same day[2] Congress proceeded to the election of a Secretary of Ordnance and Paymaster to the Board of War and Ordnance, and, the ballots being taken, Joseph Nourse, Esq., was elected.

On April 14, 1878,[3] it was—

Resolved, That the Commissary-General of Purchases have full power to appoint and remove every officer in his Department; that the Commissary-General shall from time to time, as the service may require, visit the armies and posts of the United States, and be subject to the orders of the Commander-in-Chief; that the Commissary-General shall not be obliged to reside at the place where Congress sit, but he shall there keep an office to which all general returns in his Department shall be made, and which shall be under the inspection and direction of the Board of War. * * *

On February 18, 1879,[4] considerable modification was made in the Inspector-General's Department, and the Inspector-General was made "subject to the orders of Congress, the Board of War, and the Commander-in-Chief only."

Congress also on the same day[5] proceeded to consider the report of a

[1] Jour. Cong., vol. 2, p. 442.
[2] Ibid., p. 442.
[3] Ibid., p. 511.
[4] Jour. Cong., vol. 3, p. 202.
[5] Ibid., p. 204.

committee appointed to confer with the Commander-in-Chief, and thereupon came to the following arrangement of the Department of Ordnance:

Resolved, That the commanding officer of artillery of the United States for the time being shall, under the general orders, and with the concurrence of the Commander-in-Chief, arrange and direct all business of the Ordnance Department necessary to be done in the field. The ordnance, arms, and military stores in the fixed magazines to be drawn out only by the orders of the Board of War and Ordnance—unless, in the course of the service, circumstances should occur in which the procuring such orders from the Board would, in the opinion of the Commander-in-Chief and commanding officer of artillery, occasion improper delays; and, in such cases, the commanding officer of artillery shall have the power to draw from the nearest magazines the supplies wanted for the army; and the different commissaries and directors of the magazines and laboratories shall, in such cases, immediately obey the orders of the commanding officer of artillery, informing the Board of War and Ordnance of the same. And, that the Commander-in-Chief and commanding officer of artillery may know in such cases where to send for necessary supplies, the Board of War and Ordnance shall cause monthly returns of all ordnance, arms, and military stores at the magazines and arsenals of the United States to be made to the Commander-in-Chief, who will communicate to the commanding officer of artillery the whole or any part of them, as he shall judge the good of the service requires. And as it may frequently happen that parts of the Army may be detached to such distances as to render their obtaining supplies, in the circumstances above mentioned, by the immediate orders of the Commander-in-Chief and commanding officer of artillery, inconvenient, in such cases the Commander-in-Chief and commanding officer of artillery shall give to the commanding officers of the detachment, and of the artillery annexed to it, proper directions for furnishing the detachment with the necessary supplies of ordnance, arms, and military stores; and the orders of the said commanding officers of the detachment, and of the artillery annexed to it, given pursuant to the said directions, shall be obeyed by the commissaries and directors at the magazines and laboratories as if given immediately by the Commander-in-Chief and commanding officer of artillery of the United States. Each commanding officer of artillery making these extraordinary draughts shall immediately give information thereof, and of the occasion of them, to the Board of War and Ordnance.

2. That there shall be a field commissary of military stores, to be appointed by the Board of War and Ordnance, who shall receive and issue all ordnance, arms, and military stores in the field, pursuant to the orders of the Commander-in-Chief and commanding officer of artillery; all orders for this purpose from the Commander-in-Chief to be directed to the commanding officer of artillery. The field commissary shall have so many deputies, conductors, and clerks, to be likewise appointed by the Board of War and Ordnance, as in the opinion of the Board, the Commander-in-Chief, and commanding officer of artillery, the service shall from time to time require.

3. The commanding officer of artillery, with the concurrence of the Commander-in-Chief, shall from time to time lay before the Board of War and Ordnance proper estimates (which are by the Board to be transmitted to Congress) of all ordnance, arms, and military stores necessary to be made and provided for the use of the army of the United States, that the necessary orders may be given concerning them.

4. That whenever the said commanding officer of artillery shall judge any particular directions necessary for, or alterations and improvements to be made in, the construction or preparation of ordnance, arms, and military stores of any kind, he shall communicate the same to the Board of War and Ordnance for their consideration; who shall thereupon give such orders for the artificers and laboratory men as they shall judge the good of the service requires.

5. That the field commissary of military stores, his deputies, conductors, and clerks, shall be independent of the Commissary-General of Military Stores; and the said field commissary shall make monthly returns of all ordnance, arms, and military stores re-

ceived, issued, and remaining on hand to the Board of War and Ordnance, the Commander-in-Chief, and the commanding officer of artillery. His deputies and conductors also having the chief care of the military stores with any detached parts of the army, shall make the like returns to the Board of War and Ordnance, the respective officers commanding those detachments, their commanding officers of artillery, and the field commissary; and the latter shall draw the whole into one general return monthly, one copy whereof he shall transmit to the Board of War and Ordnance, one to the Commander-in-Chief, one to the commanding officer of artillery, and a fourth to the Commissary-General of Military Stores.

6. That all moneys necessary for the department of the field commissary of military stores shall be drawn out of the military chests by warrants from the Commander-in-Chief, and officers commanding detached parts of the army respectively; and the accounts of expenditures adjusted and settled by the auditors of accounts, once in every three months, and finally transmitted to the Treasury Board.

7. That when it shall be thought necessary, the commanding officer of artillery shall send officers of artillery to visit the laboratories, foundries, and manufactories, to the intent that they may thereby gain an insight into the mechanical branches of their profession. And such number of artillery officers as, in the opinion of the commanding officer of artillery, with the concurrence of the Commander-in-Chief, can be spared from their duty in the field, shall at every convenient season be stationed at all or any of the principal laboratories, to be instructed in the laboratory art, that a knowledge thereof may be disseminated through the corps.

8. That the deputy field commissaries and conductors shall apply for and receive all ordnance, arms, and stores issued from the fixed arsenals and magazines. And to prevent any that are insufficient being carried into the field, the said commissaries and conductors shall receive none apparently unfit for service. And whenever any articles in the Ordnance Department in the field shall be so damaged that they cannot be there repaired, and are, by order of the commanding officer of artillery with the army, or with any detachment of it, sent to the Commissary-General of Military Stores, or any of his deputies, he and they shall receive the same, at such place as shall be the most convenient, and either immediately cause them to be repaired, or replace them with others fit for service, as shall be the most conducive to the public interest.

9. That the appointments of the said field commissary and his subordinate officers be as follows, viz:

	Pay per Month.	Subsis. per Month.	Rations per Day.
Of the Field Commissary	$75	$40	1
Of the Deputy Field Commissary	60	30	1
Of the Conductor	40	10	1
Of the Clerk	40	10	1

10. That there shall be one Surveyor of Ordnance, to be appointed annually from the colonels, the appointment to be made by the Board of War and Ordnance, until Congress shall direct otherwise. The officer thus appointed shall retain his rank in the artillery and all the benefits arising from it; but during the time of his surveyorship he shall not, except in extraordinary cases, or when called for by the Commander-in-Chief, perform any duty in the line. His duty as Surveyor shall be to examine into the construction, qualities, and condition of all cannon, carriages, arms, and materials for and preparation of every species of warlike stores, and to visit all the different arsenals, foundries, laboratories, and workshops belonging to the Ordnance Department of the United States, carefully noting every error and defect he shall discover, which, together with a general state of the Department, he shall report immediately to the Board of War and Ordnance, as well as the commanding officer of the artillery, with his ideas of any alterations and improvements proper to be made thereon. He shall also examine all ordnance and military stores in the field, and report the state of them to the commanding officer of artillery and the Board of War and Ordnance;

and for the purposes aforesaid, the commissaries of military stores, as well in the field as elsewhere, shall make returns to the said Surveyor, and shall expose to his view all the ordnance, arms, and stores, and all materials for the Ordnance Department in their custody. And the Surveyor shall examine the said stores, to ascertain whether the quality, quantity, and numbers agree with the return, and make report to the Board only. He shall likewise examine into the number of workmen employed in each branch of the Ordnance Department; and the principal in each branch shall make monthly returns of all work done within the month—one to the said Surveyor of Ordnance and one to the Commissary-General of Military Stores; and each of the latter hall transmit copies thereof monthly to the Board of War and Ordnance.

11. For executing the duties before mentioned, and any others relating to the Ordnance Department, which the good of the service may from time to time require, the Board of War and Ordnance shall give to the said Surveyor such instructions as they shall think proper.

12. For defraying the expenses of the said Surveyor, in the exercise of his office, he shall be allowed seventy dollars per month, besides his appointments as field officer of artillery.

13. That the commanding officer of artillery of the United States, for the performance of his duties thereinbefore prescribed, shall be allowed seventy-five dollars per month, and the commanding officer of artillery with any detached part of the army shall have a like allowance in proportion to his pay in the line.

On March 8, 1779, upon a letter from the Board of War,[1] it was—

Resolved, That all military commissions be filled up at the War Office and attested by their Secretary, and then presented for signing to the President of Congress, who shall sign the same; after signature by the President they shall be sent back to the War Office, and there registered verbatim in a book to be kept for that purpose; after having been examined by the Board, the seal of the Board of War and Ordnance, which the said Board are hereby authorized and directed to provide, shall be affixed to the certificates or attestation of the entries of all such commissions.

Resolved, That all appointments of officers in the Continental service by the respective States be, in the first instance, by warrant, certified in such manner as they shall severally direct, to the Board of War, whereupon proper commissions shall be made out in the manner above mentioned.

On March 11, 1790, on a report from the Board of War,[2] it was—

Resolved, That the engineers in the service of the United States shall be formed into a corps, and styled the "Corps of Engineers"; and shall take rank and enjoy the same rights, honors, and privileges with the other troops on the Continental establishment.

That a commandant of the Corps of Engineers shall be appointed by Congress, to whom their orders, or those of the Commander-in-Chief, shall be addressed; and such commandant shall render to the Commander-in-Chief and to the Board of War an account of every matter relative to his department.

That the engineers shall rank in their own corps according to the dates of their respective commissions.

That every year, previous to the opening of the campaign, the commandant of the corps shall propose to the Commander-in-Chief and to the Board of War such a disposition of the engineers as he shall judge most advantageous, according to the knowledge which he is supposed to have of their talents and capacity.

Resolved, That the Board of War be empowered and directed to form such regulations for the Corps of Engineers and companies of sappers and miners as they judge most conducive to the public service, and that the Board report such allowances as they judge adequate and reasonable, to be made to the officers of the Corps of Engineers for traveling charges, and when on command at a distance from camp, or in places where they cannot draw rations.

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[1] Jour. Cong.; vol. 3, p. 222.

[2] Ibid., p. 224.

On March 23, 1779, Congress took into consideration a report of a committee appointed to confer with the Commander-in-Chief, and thereupon passed an "Ordinance for regulating the Clothing Department for the Armies of the United States." The act[1] authorized the appointment of a Clothier General, to be "subject to the orders of the Board of War and Commander-in-Chief"; a sub- or State Clothier for each State, to "reside with or near the army, or such detachment thereof in which the troops of the States might be, as the Commander-in-Chief shall direct, the better to know and supply their wants"; and regimental clothiers, in the persons of the regimental paymasters. The Board of War was directed to "prepare and transmit instructions and forms, according to which the several clothiers are to conduct the business and settle their accounts," and to "report to Congress the proper salaries or allowances to be made to the several clothiers for their services."

On March 29, 1779,[2] Congress, upon a letter from the Board of War, representing that Baron Steuben, Inspector-General, had formed a system of exercise and discipline for the infantry of the United States (which had been submitted to the inspection of the Commander-in Chief, and whose remarks thereon and amendments thereto had been incorporated in the work), and that it had been examined with attention by the Board, and was highly approved, as being calculated to produce important advantages to the States, and praying that it might "receive the sanction of Congress, and be committed to the press," passed the following order:

Ordered, That the * * * regulations be observed by all the troops of the United States, and that all general and other officers cause the same to be executed with all possible exactness.

On April 8, 1779,[3] on a letter from the Board of War, it was—

Resolved, That the Board of War and Ordnance be authorized to appoint persons to purchase necessaries for the army, until the further orders of Congress.

On June 22, 1779,[4] on a report from the Board of War, it was—

Resolved, That the Adjutant-General, for the time being, be also Assistant Inspector-General.

On July 23, 1779,[5] on a plan reported by the Board of War, it was—

Resolved, That whensoever the business of the Hide Department shall require it in any State, the Board of War be authorized and directed to appoint a proper person to be Commissary of Hides therein, removable by the said Board for mismanagement, or when, by the alteration of circumstances in the particular State, no such officer is further necessary: *Provided*, That when the business of the Department will admit of it, two or more States may, by the said Board, be put under the direction of one Commissary; that the Board of War draw up instructions from time to time for the direction and government of the Commissaries of Hides in the respective States, and they are hereby enjoined to regulate their conduct by such instructions.

[1] Jour. Cong., vol. 3, pp. 231–232.
[2] Ibid., p. 237.
[3] Ibid., p. 246.
[4] Ibid., p. 310.
[5] Ibid., p. 328.

On September 15, 1779,[1] on a report from the Committee on the Treasury, it was—

Resolved, That all applications in future for moneys for the use of the different departments under the direction of the Board of War be made to the Treasury by the paymaster of the said Board, who is instructed to have them previously certified by the Board of War; and that for all sums granted in consequence of such applications the said paymaster be accountable.

On November 25, 1779,[2] it was—

Resolved, That the departments of the Quartermaster-General and of the Commissaries-General of Purchases and Issues be, for the future, under the superintendency and direction of the Board of War; and that the committee of Congress on those departments deliver over to the Board of War all papers in their hands respecting them, and thereupon be discharged.

On November 30, 1779,[3] it was—

Resolved, That the Board of War be directed to procure from the Quartermaster-General, the Commissaries-General, the Forage-Master, and the Barrack-Master-General a return of all the assistants, deputies, officers, agents, and other persons employed in their respective departments, the districts in which they are so employed, and the terms upon which they are engaged; and that such returns be made by the first day of January next.

On January 29, 1780,[4] Congress appointed a commission of three, one of whom was a member of Congress, to inquire into the expenses of the staff departments; to discharge supernumerary and delinquent officers and men; to break up unnecessary posts, and to establish posts where requisite; to stop all issues of rations and other supplies not indispensably necessary for the service; to repair to headquarters, and, in conjunction with the Commander-in-Chief, to reduce the number of horses and wagons, and to adopt the cheapest and surest methods of transportation; and to institute any other measures for promoting economy in the several departments. Another committee of three members was authorized on April 6, 1780,[5] to proceed to camp to confer with the Commander-in-Chief on the subject of the reduction of the regiments, and on the subject of a report of a commission on the arrangement of the staff departments of the army. This committee was furnished with lengthy and minute instructions by Congress on the subject of their mission,[6] and granted full powers to form plans, with the concurrence of the Commander-in-Chief, for reforming all irregularities and abuses existing in these departments, and to discharge unnecessary officers and retrench expenses.

On July 15, 1780,[7] Congress adopted new regulations for the Quartermaster-General's Department. These regulations were set forth in great detail, and required the Quartermaster-General to make returns to the Commander-in-Chief and Board of War of all officers and other persons employed, and stores belonging to the Department, and the

[1] Jour. Cong., vol. 3, p. 360.
[2] Ibid., p. 402.
[3] Ibid., p. 406.
[4] Ibid., p. 426.
[5] Ibid., p. 446.
[6] Ibid., p. 447.
[7] Ibid., p. 488.

Board of War was empowered to suspend and dismiss all supernumerary officers employed in the Department.

On August 12, 1780,[1] the Board of War, in pursuance of directions of Congress of July 26, 1780, to remove any unnecessary officers, and arrange the affairs of the Department of the Commissary-General of Military Stores in such manner as should be most conducive to the public interest, reported that they had retained in service one Commissary-General of Military Stores, one Deputy Commissary-General, one Commissary at Springfield, one Commissary at Carlisle, one Commissary in Virginia, and two or three other Commissaries at some subordinate posts or stations.

On September 25, 1780,[2] Congress increased and extended the powers of the Inspector-General's Department, and placed the discharge of its duties more immediately under the control and direction of the Commander-in-Chief and commanding officers of separate departments.

On September 30, 1780,[3] Congress revised and amended the regulations for conducting the affairs of the hospital department.

On November 30, 1780,[4] upon a letter from the Board of War, Congress resolved that there should be a Commissary-General of Purchases, whose duty it should be to purchase provisions under the direction of Congress, the Commander-in-Chief, or the Board of War, "to direct the quantities and species of provisions to be stored in the magazines of the several States, under the orders of the Commander-in-Chief, and cause the same to be forwarded to the army as occasion should require; to make monthly returns to the Commander-in-Chief and Board of War of all persons employed by him, specifying for what time and on what terms, and of all provisions received each month and remaining on hand," &c.

On December 4, 1780,[5] Congress resolved—

That no officer of the line of the Army of the United States, without express authority from Congress for that purpose, make any contract or bargain, or give any orders, for the purchase of articles for the use of the troops in the departments of the Clothier-General, Quartermaster-General, or Commissary-General of Purchases, except in cases of necessity for provisions and forage for detachments or parties in places where the same cannot be drawn from the public stores or magazines.

On February 7, 1781,[6] Congress resumed the consideration of a plan for the arrangement of the civil Executive Departments of the United States, and thereupon erected the several offices of Superintendent of Finance, Secretary at War, Secretary of Marine, and prescribed the functions of each. It was resolved—

That the powers and duty of the Secretary at War shall be as follows:

To examine into the present state of the War Office, the returns and present state of the troops, ordnance, arms, ammunition, clothing, and supplies of the armies of these United States, and report the same to Congress; to obtain and keep exact and regular returns of all the forces of the United States, and of all the military stores, equip-

[1] Jour. Cong., vol. 3, p. 507.
[2] Ibid., p. 522.
[3] Ibid., p. 526.
[4] Ibid., p. 551.
[5] Ibid., p. 553.
[6] Ibid., p. 575.

ments, and supplies in the magazines of the United States, or in other places for their use; to take the immediate care of such as are not in actual service; to form estimates of all such stores, equipments, and supplies as may be requisite for the military service, and for keeping up competent magazines, and to report the same to the superintendent of finance, that he may take measures for procuring the same in such manner as may best suit the finances of these States;[1] to prepare estimates for paying and recruiting the armies of these United States, and lay them before the Superintendent of Finance so seasonably as to enable him to make provision without delay or derangement; to execute all the resolutions of Congress respecting military preparations, and transmit all orders and resolutions relative to the military land forces of these United States; to make out, seal, and countersign all military commissions, keep registers thereof, and publish annually a list of all appointments; to report to Congress the officers necessary for assisting him in the business of his Department.

On July 18, 1781,[2] on a report of the Board of War (who were continued as a Board until the Secretary at War should enter upon his office[3]), it was—

Resolved, That the office of paymaster to the Board of War and Ordnance be abolished, and that the said paymaster do forthwith prepare his accounts for liquidation.

On July 30, 1781,[4] upon a report of the Board of War, it was—

Resolved, That the Board of War be, and they are hereby, empowered to continue such of the officers in the laboratory and artificers at Springfield as the good of the service may require, and to remove all and every other officer in the laboratory or corps of artificers at that place, and proceed to make such further reforms in the Department of the Commissary of Military Stores at other posts as they judge may conduce to the public interest.

On September 4, 1781,[5] it was—

Resolved, That all the clothing, artillery, arms, and military stores shipped in pursuance of the orders of the Hon. John Laurens, special minister to the court of Versailles, for the use of the United States, be, upon their arrival in any of the ports of these United States, delivered to the order of the Board of War, who are hereby empowered and directed to take charge and direction of the same.

On October 1, 1781,[6] in view of the likelihood of selecting an army officer for appointment to the new office of Secretary at War, it was—

Resolved, That if an officer of the army shall be appointed Secretary at War he shall retain his rank in the army, but his pay and other emoluments as an officer shall be discontinued while he acts as Secretary at War.

On the same day[7] the salary of the Secretary at War was fixed at $4,000 specie per annum.

On October 30, 1781,[8] Major-General Benjamin Lincoln was elected Secretary at War, and on November 19, 1781,[9] it was—

Resolved, That Richard Peters, esq., be authorized and requested to continue to exercise the duties of the War Department until the Secretary at War shall enter upon the execution of his office.

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[1] It was one of the duties of the Superintendent of Finance to "direct and control all persons employed in procuring supplies for the public service, and in the expenditure of the public money; and to obtain accounts of all the issues of the specific supplies furnished by the several States." (Jour. Cong., vol. 3, p. 575.)

[2] Jour. Cong., vol. 3, p. 647.

[3] Ibid., pp. 673, 683.

[4] Ibid., p. 651.

[5] Ibid., p. 662.

[6] Ibid., p. 673.

[7] Ibid., p. 673.

[8] Ibid., p. 683.

[9] Ibid., p. 690.

On November 26, 1781,[1] Major-General B. Lincoln notified Congress of his acceptance of the office of Secretary at War.

On January 3, 1782,[2] Congress resolved to reorganize the Medical Department, and empowered the Secretary at War to arrange the Department, on or before the 1st of February ensuing, agreeably to the plan fixed by Congress. It also directed that thereafter all returns theretofore ordered to be made to the Medical Committee of Congress should be made to the Secretary at War.

On January 10, 1782,[3] the Inspector-General's Department was again reorganized, and the Inspector-General and inspectors of a separate army were made "subject only to the orders of Congress, the Secretary at War, Commander-in-Chief, or commanding officer of a separate army."

On January 17, 1782,[4] upon a letter from the Secretary at War, it was—

Resolved, That the Secretary at War be, and he is hereby, authorized to appoint the following officers, for whose conduct he shall be accountable, and who shall also be removable by him, to wit: One assistant, whose salary shall be $1,250 per annum; one secretary, whose salary shall be $1,000 per annum; the clerks, whose salary shall be the same as that of those in other public offices.

On April 10, 1782,[5] a committee which had been appointed to examine the powers vested in the late Board of War made a report, recommending such of them as appeared necessary to be vested in the Secretary at War; and it was thereupon—

Resolved, That the following instructions and additional powers be given to and vested in the Secretary at War:

That the Commander-in-Chief be furnished with returns of ordnance and ordnance stores, when he shall request them from the War Office;

That the Clothier-General receive his instructions from the War Office, and that the distributions of clothing for the army be made under the Secretary at War's directions;

That the Secretary at War shall, in the absence of the Commander-in-Chief, be empowered to order the holding of general courts-martial in the places where Congress may be assembled;

That the Commissary-General of prisoners, so far as respects the securing of military prisoners and making returns of them, take his directions from the Secretary at War;

That estimates and returns from the different departments be lodged at the War Office, to be examined and approved of by the Secretary at War;

That the Secretary at War direct the building and management of laboratories, arsenals, foundries, magazines, barracks, and other public buildings, the necessity of which he is from time to time to report, and the same is to be approved of by Congress;

That the Secretary at War be empowered to send off expresses, and to provide guards for the safe conveyance of dispatches, money, and any articles necessary for the use of the army, whenever it shall appear to him to be necessary;

That the care and direction of prisoners of war be vested in the Secretary at War, so far as respects their safe keeping;

That the Secretary at War execute all such matters as he shall be directed by Con-

[1] Jour. Cong., vol. 3, p. 693.
[2] Ibid., p. 707.
[3] Ibid., p. 711.
[4] Ibid., p. 713.
[5] Jour. Cong., vol. 4, p. 8.

gress, and give his opinion on all such subjects as shall be referred to him by Congress; and if at any time he shall think a measure necessary to which his powers are incompetent, he shall communicate the same to Congress for their direction therein;

That all military and other officers attending upon or connected with the army of the United States be, and they are hereby, required and enjoined to observe the directions of the Secretary at War, in making and transmitting proper returns, and such other matters as may tend to facilitate the business of his Department.

On July 3, 1782,[1] it was resolved—

That the Secretary at War, in the absence of the Commander-in-Chief, be, and he is hereby, authorized to order all persons to be arrested and tried for disobedience of any orders which he is empowered to issue.

On October 23, 1782,[2] the Quartermaster's Department was again reorganized. The Quartermaster-General, with the concurrence of the Commander-in-Chief, was authorized to appoint all the officers in that Department for the armies of the United States; and, with the approbation of the Secretary at War, to appoint as many assistants to reside in the several States as the public service might require.

On April 4, 1783,[3] Congress resolved—

That the several States be required to suspend all enlistments for any regiment or corps in the army of the United States until the further order of Congress.

And on April 7, 1783,[4] it resolved—

That the Secretary at War, in concert with the Commander-in-Chief, be, and he is hereby, directed to consider and report to Congress, as speedily as may be, such measures as it will be proper to take in the present juncture for reducing the expenses of the United States in the War Department.

On April 11, 1783,[5] Congress proclaimed the cessation of arms, as well by sea as by land, and enjoined the observance thereof.

Major-General Lincoln tendered his resignation[6] as Secretary of War, and it was accepted to take effect on November 12, 1783, and from this period until March 24, 1785, the business of the War Office was conducted by Mr. Joseph Carleton,[7] under the designation of "Secretary in the War Office." On March 8, 1785,[8] Congress proceeded to the election of a Secretary at War, when "Henry Knox, Esq.," was elected; he gave notice of his acceptance of the office on March 17, 1785.[9]

General Washington resigned his commission as Commander-in-Chief on December 23, 1783.[10] On January 29, 1784,[11] Congress resolved—

That the principals in the several Departments of Quartermaster-General, Commissary of Military Stores, Clothier, and of the Hospital, be, and they are hereby, ordered to transmit, as soon as may be, to the War Office, to be laid before Congress, exact returns of all the stores in their respective Departments, specifying the quantity and quality of each article, where deposited, in whose care, and in what manner secured.

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[1] Jour. Cong., vol. 4, p. 44.
[2] Ibid., p. 96.
[3] Ibid., p. 184.
[4] Ibid., p. 185.
[5] Ibid., p. 186.
[6] Ibid., p. 304.
[7] Ibid., pp. 315, 332, 441, 446, 452, 488.
[8] Ibid., p. 478.
[9] Ibid., p. 490.
[10] Ibid., p. 318.
[11] Ibid., p. 332.

On May 26, 1784,[1] the following preamble and resolution were adopted by Congress:

Whereas different opinions exist in Congress respecting their authority to make requisitions on the several States for land forces in time of peace;

And whereas such a construction of the confederation as will enable Congress to make requisitions for a small number of land forces for a short period must admit an unlimited power to extend their requisitions, both with respect to numbers and time of service, and must preclude the States from a right of deliberating, and leave them only an executive authority on the subject;

And whereas Congress being authorized to make foreign and domestic loans and to issue bills of credit, if permitted to raise land forces, as aforesaid, in time of peace, will be furnished with such coercive means as must be very alarming to the several States;

And whereas standing armies in time of peace are inconsistent with the principles of republican governments, dangerous to the liberties of a free people, and generally converted into destructive engines for establishing despotism;

And whereas the United States, being remote from nations that have peace establishments, may avoid the heavy expenses thereof by providing a small number of troops for garrisoning their posts and guarding their magazines, and by being always in a state of defense on the plan of the confederation, which provides that "every State shall always keep up a well-regulated and disciplined militia sufficiently armed and accoutered, and shall provide and have constantly ready for use in public stores a due number of field-pieces and tents, and a proper quantity of arms, ammunition, and camp equipage;"

And whereas in a matter so doubtful as it respects the authority of Congress, and of such high importance to the Union, it is expedient that the delegates should take the sense of their constituents on the subject, and it is the duty of Congress in the interim to suspend the exercise of the powers aforesaid for that purpose;

It is therefore resolved, That recommendations in lieu of requisitions shall be sent to the several States for raising the troops which may be immediately necessary for garrisoning the western posts and guarding the magazines of the United States, unless Congress should think it expedient to employ the Continental troops now at West Point in the service aforesaid.

On June 2, 1784,[2] it was—

Resolved, That the Commanding Officer be, and he is hereby, directed to discharge the troops now in the service of the United States, except 25 privates to guard the stores at Fort Pitt, and 55 to guard the stores at West Point and other magazines, with a proportionate number of officers—no officer to remain in service above the rank of a captain, and those privates to be retained who were enlisted on the best terms: *Provided*, Congress, before its recess, shall not take other measures respecting the disposition of those troops. That the arrearages of their pay and rations after the 3d of November last be settled in the same manner as the accounts of the troops lately discharged; and that the Superintendent of Finance take order for furnishing them two months' pay.

On May 29, 1784,[3] the Committee of the States was instructed to revise, among other things, the institution of the War Office, and to report such alterations as it might judge necessary; and on December 8, 1784,[4] Congress, upon receiving the report, ordered—

That the election of a Secretary at War be postponed until the United States in Congress assembled shall have determined on the ordinance for regulating the War Office.

[1] Jour. Cong., vol. 4, p. 413.
[2] Ibid., p. 437.
[3] Ibid., p. 423.
[4] Ibid., p. 452.

Meanwhile Congress had determined to "recommend" to the States the raising a militia force[1] of seven hundred men for twelve months, to take possession of the western posts—as soon as evacuated by the troops of his Britannic Majesty—for the protection of the northwestern frontiers and for guarding the public stores, and the "Secretary in the War Office" was directed to take order for properly forming said troops when assembled, to arm and equip them, and to direct their destination and operations, subject to the order of Congress, and of the Committee of the States in the recess of Congress.

The ordinance for ascertaining the powers and duties of the Secretary at War was taken up for a third reading on January 27, 1785, and was passed on that day, as follows:[2]

AN ORDINANCE for ascertaining the powers and duties of the Secretary at War.

Be it ordained by the United States in Congress assembled, That the powers and duty of the Secretary at War shall be as follows, to wit:

To examine into the present state of the War Department, the returns and present state of the troops, ordnance, arms, ammunition, clothing, and supplies of the troops of these States, and report the same to Congress; to keep exact and regular returns of all the forces of these States, and of all the military stores, equipments, and supplies in the magazines of the United States, or in other places for their use; and to receive into his care, from the officers in whose possession they may be, all such as are not in actual service; to form estimates of all such stores, equipments, and supplies as may be requisite for the military service, and for keeping up competent magazines, and to report the same to the Commissioners of the Treasury of the United States, that measures may be taken in due time for procuring the same; to prepare estimates for paying and recruiting the troops of these United States; to carry into effect all ordinances and resolves of Congress for raising and equipping troops for the service of the United States, and for inspecting the said troops; and to direct the arrangement, destination, and operation of such troops as are or may be in service, subject to the orders of Congress, or of the Committee of the States in the recess of Congress; to make out, seal, and countersign the commissions of all such military officers as shall be employed in the service of the United States; to take order for the transportation, safe-keeping, and distributing the necessary supplies for such troops and garrisons as may be kept up by the United States. He shall appoint and remove at pleasure all persons employed under him, and shall be responsible for their conduct in office; all which appointments shall be immediately certified to Congress, and such certificate, or the substance thereof, registered in a book to be kept for that purpose in the office of the Secretary of Congress. He shall keep a public and convenient office in the place where Congress shall reside. He shall, at least once a year, visit all the magazines and deposits of public stores, and report the state of them with proper arrangements to Congress; and shall twice a year, or oftener if thereto required, settle the accounts of his Department.

That as well the Secretary at War as his assistants or clerks, before they shall enter on the duties of their office, shall respectively take and subscribe an oath or affirmation of fidelity to the United States, and for the faithful execution of the trust reposed in them; and which oaths or affirmations shall be administered by the Secretary of Congress, and a certificate thereof filed in his office. The oath of fidelity shall be in the words following:

"I, A. B., appointed to the office of ——, do acknowledge that I do owe faith and true allegiance to the United States of America; and I do swear (or affirm) that I will, to the utmost of my power, support, maintain, and defend the said United

[1] Jour. Cong., vol. 4, p. 441. [2] Ibid., p. 462.

States in their freedom, sovereignty, and independence against all opposition whatsoever.

And the oath of office shall be in the words following:

"I, A. B., appointed to the office of ———, do swear (or affirm) that I will faithfully, truly, and impartially execute the office of ———, to which I am so appointed, according to the best of my skill and judgment; and that I will not disclose or reveal anything that shall come to my knowledge in the execution of the said office, or from the confidence I may thereby acquire, which, in my own judgment, or by the injunction of my superiors, ought to be kept secret."

That the form of the oath of fidelity heretofore prescribed by Congress, and all former resolutions of Congress relative to the Department of War, be, and they are hereby repealed.

Done by the United States in Congress assembled, &c.

It was on the 8th of March, subsequent to this enactment, that Maj. Gen. Henry Knox, as we have seen, was elected Secretary at War.[1]

On July 25, 1785,[2] upon a letter of the Secretary at War, and the report of a committee thereon, it was—

Resolved, That the Department of Quartermaster-General be considered as ceasing on the day of passing this resolution, and that the Secretary at War and all others concerned, govern themselves accordingly.

On September 6, 1785,[3] it was—

Ordered, That the Secretary at War, as soon as may be, cause to be made and transmitted to Congress an exact return of all cannon, with their sizes and appendages; small-arms, with their accouterments; swords, pistols, wagons, tents, ammunition, camp equipage, and public stores, or property of every description, the custody of which is charged on the Department of War, distinguishing the quantity or number, quality and kind of each, and the several places of their deposits; and that he transmit a like return on the first Monday in January and first Monday in July, annually.

On June 22, 1786,[4] it was—

Resolved, That the Secretary at War direct the commanding officer of the troops to detach two companies to the rapids of the Ohio, to protect the inhabitants from the incursions and depredations of the Indians.

And on October 20, 1786,[5] it was resolved to add 1,340 men to the troops then in service, making 2,040 in all, to be formed into a legionary corps for defense against the Indians; the Secretary at War to inform the executive authorities of the respective States in which the troops were to be raised of the number and rank of the commissioned officers needed from each State in proportion to the men. But on April 9, 1787,[6] Congress directed all troops raised under the call to be discharged, except two companies of artillery at Boston, Mass., who were to be marched to Springfield, Mass., and there take station.

On October 2, 1788,[7] a committee of Congress, appointed to make full inquiry into the proceedings in the Department of War, presented to

[1] Jour. Cong., vol. 4, p. 478.
[2] Ibid., p. 553.
[3] Ibid., p. 567.
[4] Ibid., p. 655.
[5] Ibid., p. 714.
[6] Ibid., p. 733.
[7] Ibid., p. 874.

Congress a summary statement of the various branches of the Department, under the following heads, viz:

1. Of the troops in the service of the United States. These troops numbered on that date 595 men, commanded by Brigadier-General Harmer.
2. Of the clothing for the troops.
3. Of the pay of the troops.
4. Of the stations occupied by the troops on the frontiers.
5. Of the discipline of the troops.
6. Of the mode in which the troops are furnished with provisions.
7. Of the Quartermaster's Department on the frontiers.
8. Of the supplies to the troops.
9. Of the Ordnance Department.
10. Of West Point and its dependencies.
11. Of the Canadian refugees.
12. Of the Indian Department.
13. Of the Invalids.
14. Of the Army lands.
15. Of the War Office.

Under this last head, the committee say:

The business of the War Office is conducted by the Secretary at War and three clerks and a messenger, whose salaries are as follows:

The Secretary of War	$2,450
Three clerks, at $450 per annum each	1,350
Messenger, per annum	150
	3,950

The contingent expenses of the office for stationery, firing, candles, and necessary conveniences for the papers, are averaged on the three last years to amount to about $176 for each year.

The office of assistant secretary, whose salary was $1,000 per annum, has been discontinued in this office since the commencement of the year 1786.

The accounts of pay and subsistence of the troops are examined and certified at the pay-office and transmitted to the War Office, on which the Secretary at War issues his warrants for the amount on the paymaster.

Regular registers are kept in the War Office of all warrants so drawn, specifying the objects for which they were granted.

Upon the foregoing statement, your committee beg leave to observe that, having carefully examined every part of it, they are of opinion that the arrangement of the business is judicious, and that the duties of the office are executed with ability and punctuality which reflect great honor on the Secretary at War.

Your committee think it their duty further to remark that great care appears to have been taken by the Secretary to reduce the expenses of his Department, as well by dispensing with the office of assistant secretary, formerly attached to it, and which has never been annulled by Congress, as by various economical arrangements and reforms in the other branches thereof.

THE WAR DEPARTMENT FROM 1789.

UNDER THE AUTHORITY OF THE CONSTITUTION AND THE LAWS PASSED IN PURSUANCE THEREOF.

The Secretary at War under the ordinance of February 7, 1781, became the legal costodian in place of the old Board of War, whose functions ceased[1] when the Secretary entered upon the execution of the duties of his office, of all the warlike stores of the country and of their depositories, and became thereafter the executive officer of the Confederation in all that related to the military service. Vested with authority "to carry into effect all ordinances and resolves of Congress for raising and equipping troops for the service of the United States," and "to direct the arrangement, destination, and operation of such troops," subject to the orders of Congress, or of the Committee of the States in the recess of Congress, it will be perceived that he was endowed with functions in respect to military matters little short of those vested in the Chief Executive under our present Constitution. By this latter instrument, adopted in 1789, the President of the United States was made the "Commander-in-Chief of the Army and Navy." In the organization of the Government under this new instrument, Congress proceeded, in 1789, to the establishment of the various great Executive Departments by whose agency the details of the public business were to be transacted, and on August 7 it enacted[2] "that there shall be an Executive Department, to be denominated the Department of War; and that there shall be a principal officer therein, to be called the Secretary for the Department of War, who shall perform and execute such duties as shall, from time to time, be enjoined on or intrusted to him by the President of the United States, agreeable to the Constitution, relative to military commissions or to the land or naval forces, ships, or warlike stores of the United States, or to such other matters respecting military or naval affairs as the President of the United States shall assign to the said Department or relative to the granting of lands to persons entitled thereto for military services rendered to the United States, or relative to Indian affairs; and, furthermore, that the said principal officer shall conduct the business of the said Department in such manner as the President of the United States shall from time to time order or instruct." The fourth section of the act directed that the Secretary should "forthwith, after his appointment, be entitled to have the custody and charge of all records, books, and papers in the office of Secretary for the Department of War heretofore established by the United States in Congress assembled."

[1] Jour. Cong., vol. 3, p. 683; vol. 4, p. 8.

[2] 1 Stat. Large, 49.

It will thus be seen that the new Secretary of War was to supplant the old Secretary at War under the Confederation; and was to take possession of and be installed in his very office—even the records, books, and papers of that office being taken into his hands; and that, under the direction of the President, he was, in addition to business relating to Indian affairs and pensions, to perform such duties relative to "matters respecting military or naval affairs," as should from time to time be enjoined on or intrusted to him by the President. The superior executive functions respecting military affairs which were vested in the Secretaryship under the Confederation being absorbed into the higher office of President under the new Constitution, without any provision being made by law for the discharge of the remaining duties of the old Secretary except by the new Secretary under this law, it is reasonable to presume that the new Secretary's functions were allowed by the President to remain the same as those of the old Secretary, so far as the latter were not inconsistent with the Constitution or the supremacy of the President as the chief executive power. Any subsequent alteration of these functions and duties, therefore, must be sought for in the laws of Congress and the Presidential orders affecting the Secretary's office.

An act of May 8, 1792,[1] directed that all purchases and contracts for supplying the troops in the service of the United States with provisions, clothing, supplies in the Quartermaster's Department, military goods, Indian goods, and all other supplies or articles for the use of the Department of War, should be made by, or under the direction of, the Treasury Department, and in 1795,[2] the office of Purveyor of Public Supplies was erected in the Treasury Department for the purpose; but in 1798[3] the Purveyor was placed under the orders of the *Secretary of War* for the procuring and providing of all kinds of military stores and supplies.

In March, 1794,[4] an act was passed providing for the fortification, under the direction of the President, of certain ports and harbors on the eastern seaboard of the United States, and for the procurement of 100 32-pounders, 100 24-pounders with carriages and implements, and carriages and implements for 150 other cannon, and also 250 tons of cannon shot. The act also authorized the reception by the United States of lands ceded by the several States for sites for said fortifications. This was the first movement for the establishment of sea-coast fortifications, and the business connected with this undertaking fell under the direction of the Department of War, and was subsequently reported upon to the President by the Secretary of War.[5]

In December, 1793,[6] a statement was laid before the President by the *Secretary of War* of the ordnance, arms, and military stores in possession of the United States. He suggested the erection of the necessary

[1] Stat. Large, 280.
[2] Ibid., p. 419.
[3] Ibid., p. 610.
[4] 1 Stat. Large, 345.
[5] Am. State Pap., Mil. Aff., vol. 1, p. 72–74 *et passim.*
[6] Ibid., p. 44.

arsenals and magazines for their proper storage, as well as the advisability of undertaking the fabrication of cannon, arms, and ammunition. This communication being laid before Congress, an act was passed April 2, 1794,[1] providing for the erection, under the direction of the President of the United States, of three or four arsenals with magazines, and directing the establishment of national armories, with officers to be appointed by the President, and as many workmen as the *Secretary of War* might deem necessary, not over one hundred. An officer styled Superintendent of Military Stores was also directed to be appointed, whose duty it was, under the direction of the *Secretary of War*, to superintend the receiving, safe-keeping, and distribution of the military stores of the United States, and to call to account all persons to whom the same might be intrusted.

Further appropriations were made June 23, 1797,[2] for fortifying the ports and harbors of the United States; and on April 27, 1798,[3] an additional regiment of artillerists and engineers was authorized for employment, in detachments or otherwise, in the field or in the fortifications on the sea-coast; and the *Secretary of War* was directed to provide, at the public expense, under the direction of the President, all necessary books, instruments, and apparatus, for the use and benefit of the said regiment. In May, 1798,[4] in anticipation of the breaking out of war between this country and France, additional appropriations for the fortifications were made, as well as a large amount for the purchase, under the direction of the President, of cannon, small arms, and ammunition, and military stores for the public safety and defense. The act authorized the President, in case the cannon and small arms could not be purchased with certainty and dispatch proportionate to the demands of service, to take, by lease or sale in fee, one or more suitable places where cannon or small arms might be advantageously cast and manufactured, and to cause suitable artisans and laborers to be employed, and to appoint persons to superintend the works, under the direction of the *War Department*. Congress also authorized, by act of May 28,[5] of that year, the raising of a "provisional" army, and empowered the President, whenever he should deem it expedient, to appoint, by and with the advice and consent of the Senate, a "commander of the army," who, "being commissioned as lieutenant-general might be authorized to command the armies of the United States"—the latter to "appoint from time to time such number of *aides*, not exceeding four, and secretaries, not exceeding two, as he might judge proper, each to have the rank, pay, and emoluments of a lieutenant-colonel." The same act also authorized the appointment of an Inspector-General, an Adjutant-General, a Quartermaster-General, a Physician-General, and Paymaster-General, with such Assistant Inspectors to "every separate portion of

[1] 1 Stat. Large, 352.
[2] Ibid., p. 521.
[3] Ibid., p. 552.
[4] Ibid., p. 555.
[5] Ibid., p. 558.

the army" as might be necessary, who should be deputy Adjutant-Generals thereof, and subinspectors to each brigade and corps, &c.

The "commander of the army," and other officers to be appointed by virtue of the act, were to continue in commission during such term only as the President should judge requisite for the public service, the whole or any portion of the provisional army to be discharged whenever the President should judge the measure consistent with the public safety.

On June 22[1] a supplementary act was approved, authorizing the President to proceed to appoint and commission as many of the officers authorized by the previous act as in his opinion the public service should more immediately require, with the proviso that the officers so appointed should not be entitled to any pay, subsistence, or other emoluments by reason of such commissions, until they should be employed in the actual service of the United States.

In the emergency that was then upon the country "the opinion was universally entertained that Washington must be called on to take the command of the armies." "The weight of his name and character was of the utmost importance to produce unanimity in the leaders and to secure the confidence and support of the people." President Adams had said of him in his inaugural address in 1797: "His name may still be a rampart, and the knowledge that he lives a bulwark against all open or secret enemies of his country's peace." Moved by these political considerations, therefore, President Adams wrote him at Mount Vernon, on the date of the approval of the last above-mentioned act (June 22, 1798): "We must have your name, if you will in any case permit us to use it. There will be more efficacy in it than in many an army." The Secretary of War, on June 26, wrote: "You see how the storm thickens, and that our vessel will soon require its ancient pilot. Will you—may we flatter ourselves that, in a crisis so awful and important, you will—accept the command of all our armies? I hope you will, because you alone can unite all hearts and all hands."

Answering the President and Secretary of War on July 4, 1798, General Washington, referring to his age and his retirement from public life, intimated his unwillingness to remain an idle spectator in case of "actual invasion of our territorial rights." Without waiting for his reply, however, the President had, on the 2d of the month, nominated him "to be lieutenant-general and commander-in-chief of all the armies raised, or to be raised, in the United States." The Senate advised and consented to the appointment, "agreeably to the nomination," on July 3, and the President, in communicating to him on the 7th the step he had ventured to take, said: "If it had been in my power to nominate you to be President of the United States, I should have done it with less hesitation and more pleasure."

In his letter of acceptance of July 13 General Washington said: "I have finally determined to accept the commission of Commander-in-

[1] 1 Stat. Large, p. 569.

Chief of the armies of the United States, with the reserve only that I shall not be called into the field until the army is in a situation to require my presence, or it becomes indispensable by the urgency of circumstances;" and further, in pursuance of the proviso in the act of June 22, he said: "I take the liberty, also, to mention that I must decline having my acceptance considered as drawing after it any immediate charge upon the public, and that I cannot receive any emoluments annexed to the appointment before entering into a situation to incur expense."[1]

The act of March 3, 1799,[2] for "the better organizing of the troops of the United States, and for other purposes, enacted, by its ninth section, "that a commander of the army of the United States shall be appointed and commissioned by the style of 'General of the Armies of the United States,' and the present office and title of Lieutenant-General shall thereafter be abolished."

To understand this legislation and its legal effect, we must have recourse to the history of the times, which may be found succinctly stated by the Attorney-General in an official opinion delivered August 24, 1855,[3] as follows:

I have said that this series of acts appertained to the hostilities between the United States under the administration of President Adams and the French Republic under that of the Directory. It was a state of partial or imperfect war; that is, war with limited range, and objects wholly maritime. (Bas *vs.* Tingy, 4 Dallas, p. 37–43.) We had broken off ordinary diplomatic relations with France. A special mission to that country from the United States had failed by reason of misconduct of the Directory. We had annulled all existing treaties with France. We were capturing one another's ships. We were engaged on one side in earnest preparation for the moment when the partial war should become a perfect one by land as well as by sea. The War Department had, for greater efficiency, been subdivided, and the Navy Department organized. [Act of April 30, 1798.] Congress was placing at the disposal of the President all the means, material and personal, of raising a large army for the defense of the United States; and General Washington was called from his retirement of Mount Vernon to be commander of this army, with the rank and title of Lieutenant-General. Such was the notorious history; but in the less notorious, and, so to speak, the internal history, is to be found the true explanation of events. What was heretofore imperfectly known is now thoroughly understood by means of the published correspondence of Washington, Jefferson, Hamilton, Pickering, Walcott, and lastly of Adams, viz, that while the Cabinet of the President was earnest for active and complete war he held back; that he looked to the renewal of negotiations, which they strenuously opposed; that some of them labored under the extraordinary delusion that the Bourbons were on the immediate eve of being restored by the arms of England; and that he, with fuller knowledge and clearer perception of the state of things in Europe, already discerned in the horizon the rising star of Napoleon; and finally that they differed on this very point of the military title of the person to command the army, he preferring "Lieutenant-General" to "General of the Armies of the United States," which, in his view, touched, if it did not encroach upon, the constitutional functions of the President. * * * General Washington died in office under this commission [Lieutenant-General]; the proposed new appointment of General was not conferred upon him. (Am. St. Pap., Mil. Aff., vol. 1, p. 147.) The Executive journals show this, and also that on the

[1] Hickey's Constitution, pp. 231–239. [2] 1 Stat. Large, 749. [3] 7 Opin., 453.

death of General Washington no appointment was made in his place to the new office of General. Of course, therefore, the ninth section of the act of 1799 remained without effect—not, in fact, abolishing either the office or the pay of the Lieutenant-General. Meanwhile a new embassy to France had been appointed (Sen. Ex. Jour., vol. 1, p. 317); it had proceeded to Europe; the Directory had fallen; and Napoleon Bonaparte had become First Consul, November 9, 1799, and there was every prospect of a speedy settlement of our difficulties with France. Under these circumstances an act was passed, on the 20th of February, 1800, to suspend enlistments under the act of July 16, 1798 (2 Stat. Large, p. 7), and on the 14th of May, 1800, an act supplementary thereto, which authorized the President to suspend any further military appointments under the act of July 16, 1798, and under the *ninth section* of the act of March 3, 1799, and also authorizing him to discharge certain officers, but which repealed nothing of any previous statute. (2 Stat. Large, p. 85.) Here it needs only to remark that by this act the omission of the President to appoint a "General," and thus to produce the contingency on which the office of Lieutenant-General would become abolished, was expressly sanctioned by Congress.

The act of May 28, 1798,[1] authorizing the appointment of the Lieutenant-General, empowered the President to loan, at the request of the executives of the States from which militia might be called forth for active service under the orders of the President, and at the request of volunteer corps appearing to be unavoidably deficient, a supply of field artillery, arms, and accouterments from the arsenals of the United States, proper receipts and security being given to be accountable to return the same, the accidents of the service excepted. It also authorized the President to cause to be purchased and procured a quantity of "caps, swords, or sabers, and pistols with holsters," sufficient for 4,000 cavalry, to be supplied to any corps of cavalry called into actual service, as a loan upon the same terms and conditions as above.

Act of June 22, 1798,[2] authorized the sale of artillery, arms, &c., to volunteers, if they desired to purchase them, the proceeds to be applied to the purchase of other artillery, arms, &c., as the President might direct. Act of July 6,[3] authorized the procurement of 30,000 stands of arms to be held for sale to the governments of the respective States, or the militia thereof, or for delivery to the militia when called into the service of the United States, proper receipts and security in which last cases being required for the safe return of the same.

March 2, 1799,[4] the Medical Department of the army and navy of the United States was established, the Physician-General being empowered to draw up a system of directions, police regulations, &c., for the hospitals of the Department, these directions, &c., to be subject, in the first instance, to the approbation and revision of the Commander-in-Chief, the commander of a separate army, or in a separate district, as the case might be, and eventually to the control of the President of the United States.

As early as 1794,[5] Congress had laid an embargo on the exportation of any "cannon, muskets, pistols, bayonets, swords, cutlasses, musket-

[1] 1 Stat. Large, 560.
[2] Ibid., 569.
[3] Ibid., p. 576.
[4] Ibid., p. 721.
[5] Ibid., p. 369.

balls, lead, bombs, grenades, gunpowder, sulphur, or saltpeter," and had encouraged the importation of all articles of these classes by admitting them free of duty. These materials had theretofore been directed by law to be obtained for the use of the United States through the Treasury Department; but in 1798 (act of July 16,)[1] Congress directed that thereafter "all purchases of and contracts for supplies for the military * * * service of the United States shall be made by or under the direction of the *chief officer of the Department of War;*" and the Purveyor of Public Supplies was directed to execute all orders received from him for procuring and providing all kinds of stores and supplies. By act of March 3, 1799,[2] the *Secretary of War* was himself authorized to "make purchases and enter, or cause to be entered into, all necessary contracts or obligations" for providing "in each and every year all clothing, camp utensils, and equipage, medicines, and hospital stores necessary for the troops and armies of the United States for the succeeding year."

These extracts from, and references to, the laws show the general character of legislative provisions up to this period for placing the country in a condition of defense. The procurement of provisions, clothing, and quartermaster's supplies, military goods, arms, and other stores for the military service, medicine, and hospital stores, was to be effected either by the *Secretary of War* himself, or by the Purveyor of Public Supplies acting under his direction. An armory was in operation at Springfield, Mass., under the direction of the *Secretary of War*, which, from January, 1795, to September, 1799, turned out 6,224 stands of arms, the production of the entire establishment during the last-named month being at the rate of 17 stands per day, employing 130 to 150 workmen.[3] A few private establishments were also engaged, under contracts with the Government, in the manufacture of arms.[4] Cannon of foreign and domestic manufacture were procured through the Treasury Department, with whom contracts were made in 1794 and 1796 by founders in Rhode Island and Maryland, for the delivery of 84 32-pounders, 234 24-pounders, and 40 12-pounders, to be of home production; but of this number only 34 32-pounders, 146 24-pounders, and 3 12-pounders had been delivered by April, 1798.[5] The fortifications on the sea-coast thus far erected were embarrassingly few in number, of the most primitive construction, and none calculated for an armament heavier than a few 32 pounders and 24-pounders.[6]

These were the early days of the young Republic, and these were the only governmental provisions and agencies existing in those times for meeting the contingency of a war threatened by a powerful and victorious enemy. The paucity of the national resources; the lack of adequate means of defense; the want of harmonious adjustment of the

[1] 1 Stat. Large, p. 610.
[2] Ibid., p. 749.
[3] Am. State Pap., Mil. Aff., vol. 1 pp. 131, 132.
[4] Ibid., p. 110.
[5] Ibid., p. 123.
[6] Ibid., p. 110 *et seq.*

machinery of National and State governments; the political dissensions of the times; the hitherto unsettled relation of the militia to the National Government; the question of arming them for war; the absence of all precedent for the guidance of the statesmen in this hour of trial of a new, untested, and complicated form of government—in the presence of all these embarrassments, what wonder that the Government, in its perplexity, should turn towards the hero of the Revolution as its military leader, and confer upon him rank comporting with the dignity of his exalted character—a character whose various talents, "combining all the capacities of a statesman with those of a soldier, fitted him alike to guide the councils and the armies of our nation." The choice of his military title was made by Congress in 1798, and was fixed as Lieutenant-General. On the 31st December of that year,[1] however, a communication from the Secretary of War, on military subjects, was transmitted to Congress by the President, in which occurred the following in regard to the term "lieutenant-colonel," which was the designation at that period of the commanding officer of a regiment:

> The term "lieutenant-colonel" in our present establishment has a relative signification, without anything in fact to which it relates. It was introduced during our Revolutionary war to facilitate exchanges of prisoners, as our then enemy united the grade of colonel with that of general. But the permanent forms of our military system ought to be regulated by principle, not by the changeable and arbitrary arrangement of a particular nation. The title of colonel, which has greater respectability, is more proper for the commander of a regiment, because it does not, like the other, imply a relation having no existence.

By the law which followed (March 3, 1799), the title of lieutenant-colonel was retained in the army, but that of "General of the Armies of the United States" was created to take the place of *lieutenant*-general, as we have seen. This grade of "General of the Armies of the United States," however, was never conferred by the President, who considered it as interfering with the Constitutional functions of the Presidential office in its relations to the army of the United States.

The act to reduce and fix the military service at a peace basis in 1802,[2] provided for one brigadier-general, one adjutant and inspector general, one paymaster, one *aide* to the brigadier-general, one regiment of artillerists, two regiments of infantry, and the corps of engineers. Three military agents were provided by this act, whose duty it was to "purchase, receive, and forward to their proper destination all military stores and other articles for the troops in their respective departments, and all goods and annuities for the Indians, which they might be directed to purchase, or which might be ordered into their care by the *Department of War*." They were "to account with the *Department of War*, annually for all the public property which passed through their hands." By the same act the paymasters were given charge of the clothing of the troops. In this year the Corps of Engineers was constituted a Military

[1] Am. State Pap., Mil. Aff., vol. 1, p. 124. [2] Stat. Large, 132.

Academy at West Point, the superintendence of the academy being placed under the principal engineer.[1]

Much solicitude for the proper organization, armament, and disciplining of the militia of the country was manifested in Congress during the period following the passage of the act of 1792, to "more effectually provide for the national defense by establishing an uniform militia throughout the United States," and measures looking to the improvement of the system laid down by that act were constantly engaging the attention of that body for a number of years afterwards. In 1794[2] a committee of the House appointed to prepare a plan for the better organizing, arming, and disciplining the militia, reported that—

> The principal difficulties and inconveniences which have occurred in the execution of the militia system particularly respect the incompetent provision for arming them, and for calling them forth to execute the laws of the United States, suppress insurrections, and repel invasions. It appears to the committee that the principal defects in the existing provisions for arming the militia consist in the want of a competent *source* of supplying the arms, the want of some provision for *furnishing* persons with arms who may be deemed unable to furnish themselves, and the want of adequate and uniform penalties to *enforce* a compliance with the requisitions of the existing militia laws.

In 1803[3] a committee of the House to whom was referred that part of the President's message of December 15, 1802, inviting a review of the militia laws, reported a resolution requesting the President to write to the Executive of each State—

> Urging the importance and indispensable necessity of vigorous exertions on the part of the State governments to carry into effect the militia system adopted by the national legislature agreeably to the powers reserved to the States respectively by the Constitution of the United States, and in a manner the best calculated to insure such a degree of military discipline and knowledge of tactics as will, under the auspices of a benign Providence, render the militia a sure and permanent bulwark of national defense.

An act[4] was passed in this year, in addition to the militia act of 1792, which contained the following inefficient provision:

> That every citizen duly enrolled in the militia shall be constantly provided with arms, accouterments, and ammunition, agreeable to the directions of the said act, from and after he shall be duly notified of his enrollment; and any notice or warning to the citizen so enrolled to attend a company, battalion, or regimental muster or training which shall be according to the laws of the State in which it is given for that purpose, shall be deemed a legal notice of his enrollment.

Again, in January, 1806, the subject of a new organization and classification of the militia was suggested by the President, but it was not deemed expedient by Congress at that particular time to derange the existing system of 1792, the militia being considered competent to a defense against an invading enemy, and a change at that juncture being considered as putting too much at risk.[5] A committee was, however,

[1] 2 Stat. Large, 132.
[2] Am. State Pap., Mil. Aff., vol. 1, p. 107.
[3] Ibid., p. 163.
[4] 2 Stat. Large, 207.
[5] Am. State Pap., Mil. Aff., vol. 1, p. 189.

appointed by the House, with instructions to inquire what measures were necessary to complete the *arming* of the militia, and that committee reported[1] as follows:

That, by the laws of the United States, each citizen enrolled in the militia is put under obligations to provide himself with a good musket or rifle, and all the other military equipments prescribed by law. From the best estimate which the committee have been able to form there are upwards of 250,000 fire-arms and rifles in the hands of the militia, which have, a few instances excepted, been provided by, and are the property of, the individuals who hold them. It is highly probable that many more of the militia would have provided themselves with fire-arms in the same way, if they had been for sale in those parts of the United States where the deficiencies have happened; but the wars in Europe have had a tendency to prevent the importation of fire-arms from thence into the United States, which, together with the limited establishments for the manufacture of that implement in the United States, has rendered it impossible for individuals to procure them. There are several State magazines of fire-arms, but the amount of the number of stands has not been ascertained. There are in the magazines of the United States about 120,000 fire-arms and rifles fit for use, and about 12,000 which need repairs. It is conceived that the number of fire-arms in the public magazines is not greater than ought to remain there in time of peace. And the committee are of opinion that, to provide for the exigency of war, it will be expedient to extend the manufacture of fire-arms in the armories of the United States, as far as can conveniently be done without the erection of new buildings; to effect which it will be necessary to appropriate for that purpose $62,100, in addition to the sums reported in the general estimate.

The act of February 24, 1807,[2] authorizing the President to accept the services of a number of volunteer companies—artillery, cavalry, and infantry—not to exceed 30,000 men, directed that the companies should—

Be clothed and furnished with horses at their own expense, and armed and equipped at the expense of the United States after they shall be called into service, except such of them as may choose to furnish their own arms.

And it was provided—

That in case any volunteer above mentioned while in actual service shall sustain any damage by injury done to his horse or such other equipments as shall have been furnished at his own expense, or by loss of the same without any fault or negligence on his part, a reasonable sum, to be ascertained in such manner as the President of the United States may direct, shall be allowed and paid to such volunteer for each and every such damage or loss.

In November, 1807, a resolution of the House directed a committee to "inquire into the expediency of selling to individual States or Territories, which may wish to purchase, any arms or ordnance owned by the United States, and which may be parted with without injury to the public"; and, upon their favorable recommendation of the measure, Congress directed[3] sales to be made to the States, the proceeds to be applied to the purchase or manufacture of other arms for the use of the United States.

Many States were not, in these times, well provided with arms, and were anxious to purchase from the United States, there being great difficulty in getting arms from abroad.

[1] Am. State Pap., Mil. Aff., vol. 1, p. 198. [2] 2 Stat. Large, 419. [3] Ibid., 481.

A resolution[1] offered at the same session, by Mr. Randolph of Virginia, expressed the sense of the House—"*that provision ought to be made by law for arming and equipping the whole body of the militia of the United States*"; and a bill being brought in for the purpose it was, after much debate, finally passed, and became a law on April 23, 1808.

In the bill, as originally introduced, the amount of the annual appropriation intended to be made was left blank. In Committee of the Whole[2] it was proposed to fill the blank with the sum of $1,000,000, which amount, it was asserted, would arm but about 100,000 men, in which ratio it would require five or six years to arm the whole body of the militia, excluding from consideration the intermediate increase of population. It was confessed that the people of the country at that time were unable to manufacture arms for themselves, even with the aid of the Government, and it was therefore urged to be the duty of the nation itself to provide arms for them, it being a hardship in the existing militia laws to require every man to provide his musket at his own expense. It was claimed at the same time that the arms, when once bestowed by the National Government, should be held independent of it, and not be subject to recall at the option of that power; the intention being to secure permanency to the freedom of the individual, "for," as Mr. Randolph said, "it was not possible that a nation, free and armed, could have their liberties taken from them until they were reduced to that state that it is impossible to keep them free, nations, in this respect, being like men; if once they become dissolute it was impossible to compel them to attend to their true interests; but at the same time every encouragement should be given to men and nations, by a good education and good habits, to induce them to remain free and independent."

It was the opinion of some of the statesmen of that period that the arms should be given gratuitously to the individuals; some were for selling the arms to them, some for keeping them in arsenals for the use of the militia, and some were in favor of sending them to the governments of the several States and Territories *in trust* for such portions of the whole body of the militia as were residents within their respective limits. This latter method was the one finally adopted.

The amount of the permanent annual appropriation was fixed at $200,000, after the respective sums of $1,000,000, $500,000, $450,000, $400,000, and $300,000 had been successively proposed and rejected.

The first arms procured under this enactment[3] were made by private parties under contract with the War Department.[4] Large advances of public moneys were made by the Secretary of War to these contractors for the purpose of building up the gun-making industries of the country,

[1] Annals of Cong., Tenth Congress, first session, vol. 2, pp. 1005, 1055.

[2] Ibid., pp. 2175, 2197.

[3] Arms are supplied to the militia of the several States at the present day under the law of April 23, 1808, now embodied in the Revised Statutes.

[4] Am. State Pap., Mil. Aff., vol. 1, p. 335.

in aid of the National Armories, so that the demand for military weapons might thereafter be supplied by home production instead of by foreign importation.

The advisability of making preparations for whatever events might affect our relations with foreign nations growing out of the contests between France and the other European powers was pressed upon the attention of Congress at various times throughout President Jefferson's administration; and in February, 1808,[1] the Secretary of War (General Henry Dearborn) proposed the expediency of augmenting the army by the addition of 24,000 men. In his communication, which was submitted by the President to Congress, he said:

> In the event of war, it will, I presume, be considered necessary to arrange our military force into separate departments, and to have a commander to each department, and, of course, to have no such officer as a Commander-in-Chief; and until a larger army shall be raised than is now proposed it may not be advisable to have any officers above the rank of brigadier-general; of that grade it may be proper to have four or five, as soon as a suitable proportion of the troops is raised.

Congress authorized the raising of an additional force, by act of April 12, 1808,[2] and two brigadier-generals, in addition to the one already in service, were also authorized. These three brigadiers exercised their commands independently of each other, being each of them controlled and directed by the War Department. Meanwhile the existing system of procurement and distribution of quartermaster and other supplies, by means of the military agents, was found to occasion inconveniences and embarrassments, resulting in positive neglect and loss of public property. The serious defects of the system then in vogue were pointed out by the Secretary of War on January 1, 1810,[3] in a communication to the Senate Military Committee. No action was taken on the subject, however, until 1812.

During the period anterior to the war of 1812, all business relating to the military branch of service (as well as naval, up to 1798) had been transacted through the office of the *Secretary of War*, or under the direction of that officer. This business had found its way into his hands either through direct assignment by the President, or by the naming of the Secretary in the laws passed by Congress and approved by the President. The relations between the President and Secretary of War were left untrammeled by any restrictions in the act of 1789, creating the War Department, and it is a noticeable feature that nearly all the earlier acts in relation to military affairs were addressed to the President of the United States. The reasons for this may be surmised from the fact that the Secretary of War had been made the legal successor in office to the Secretary at War under the Confederation, the latter having possessed prerogatives in certain particulars coextensive with those of the President under the new Constitution. It became necessary, therefore, in order to secure a harmonious adjustment between the

[1] Am. State Pap., Mil. Aff., vol. 1, p. 227.
[2] 2 Stat. Large, 481.
[3] Am. State Pap., Mil. Aff., vol. 1, p. 256.

President and the Secretary of War under the new Government, to make the latter entirely subordinate to and dependent upon the former in all matters properly falling within the limits of his Department. In course of time this adjustment became fixed and well-settled, and became the subject of legislative recognition. We therefore find the laws beginning to name the Secretary of War in connection with matters falling within his Department as the active agent of execution—in all which cases the Secretary became the exclusive agent, subject only to the supervising control of the Chief Executive, whose duty it is simply to take care that the laws are faithfully executed. As an illustration of this exclusive agency, when the agent is nominated in the law, the following case may be put: The same session of Congress (second session, Fifth Congress) which created the grade of lieutenant-general, also prescribed that all purchases of and contracts for supplies or services for the military service should be made by, or under the direction of, the *chief officer of the Department of War*. Here the jurisdiction over military purchases and contracts was vested in the Secretary of War, to the exclusion of every other officer of Government, whether of the army or not. Neither Lieutenant-General Washington nor the President himself could, in face of this enactment, have displaced the civil incumbent of the War Department from his statutory jurisdiction, on any imaginary principles of *military* adminstration or command. General Washington certainly never dreamed of such a thing, for, knowing that his sphere of usefulness was in the "field," and that it was expected of him to give his services in that quarter, he, in accepting his commission, begged that, on account of the infirmity of age, he might not be required to take the "field" until the urgency of circumstances should render it necessary. The military powers and functions which his latter commission bestowed on him must not be confounded with those vested in him during the revolutionary war, since at that time it could hardly have been said that an organized National Government, complete in the necessary details of administration, was in existence, and the powers of the General and Commander-in-Chief of the Armies of the United Colonies were therefore limited, in the exigencies of those times, by such bounds only as the exalted patriotism of that officer inspired him to place upon them. Through his success, the establishment of national civil Government, combining all the limitations upon the powers of subordinate agents which human wisdom had demonstrated to be necessary, was rendered possible. In accepting a military commission from this organized Government after its erection, can it be said that, in the absence of overwhelming disaster or hopeless emergency, authority flowing from such commission permitted him to ignore any one safeguard which had been erected in the interest of civil government? General Washington's own life and utterances vindicate him from so erroneous a notion.

The idea of maintaining a standing army, especially in times of peace, had ever been repulsive to those sages and patriots by whom the

foundations of our Government were laid; and in the years just succeeding the organization of the Government under the Constitution, we find various measures suggested whereby to obviate, as far as possible, the necessity for the maintenance by the general Government of a standing army in the midst of the people. In submitting his celebrated scheme for the arrangement of the militia in 1790,[1] General Henry Knox (Secretary of War at that time, and compatriot of Washington in the revolutionary war) said:

It is the misfortune of modern ages that governments have been formed by chance and events, instead of system; that, without fixed principles, they are braced or relaxed from time to time according to the predominating power of the rulers or the ruled—the rulers possessing separate interests from the people, excepting in some of the high-conditioned monarchies, in which all opposition to the will of the princes seems annihilated. Hence we look around Europe in vain for an extensive government, rising on the power inherent in the people, and performing its operations entirely for their benefit. But we find artificial force governing everywhere, and the people generally made subservient to the elevation and caprice of the few—almost every nation appearing to be busily employed in conducting some external war, grappling with internal commotion, or endeavoring to extricate itself from impending debts, which threatened to overwhelm it with ruin. Princes and ministers seem neither to have leisure nor inclination to bring forward institutions for diffusing general strength, knowledge, and happiness; but they seem to understand well the Machiavelian maxim of politics—divide and govern. * * * The modern practice of Europe with respect to the employment of standing armies has created such a mass of opinion in their favor that even philosophers and the advocates for liberty have frequently confessed their use and necessity in certain cases. *But whoever seriously and candidly estimates the power of discipline and the tendency of military habits will be constrained to confess that, whatever may be the efficacy of a standing army in war it cannot in peace be considered as friendly to the rights of human nature.* The recent instance in France cannot with propriety be brought to overturn the general principle, built upon the uniform experience of mankind. * * * An energetic national militia is to be regarded as the *capital security* of a free republic, and not a standing army, forming a *distinct class* in the community. It is the introduction and diffusion of vice and corruption of manners into the mass of the people that render a standing army necessary. It is when public spirit is despised, and avarice, indolence, and effeminacy of manners predominate and prevent the establishment of institutions which would elevate the minds of the youth in the paths of virtue and honor, that a standing army is formed and riveted forever.

The spirit of this remarkable document will be found, upon examination, to have exercised a controlling influence over the policy of the Government in respect to military affairs for a long period after its promulgation, and its sentiments are traceable in the drift of Congressional legislation for many years thereafter. The act of 1792, providing for the *national* defense by the establishment of an uniform militia throughout the United States, and the act of 1808 making a permanent annual appropriation of $200,000 for arming and equipping the whole body of the militia, are both embodied in the Revised Statutes of the present day.

At no time subsequent to 1789 down to the period of the War of 1812, except in 1789–1800, did the military force raised by the Govern-

[1] Am. State Pap., Mil. Aff., vol. 1, p. 7.

ment exceed 5,500 men.[1] The direction of all purchases of and contracts for supplies for the military service had been vested by the law of 1798 in the Secretary of War. The business of the Indian Department, military lands, and invalid pensions; the supervision of the erection of fortifications; the erection and care of arsenals; the replenishment and distribution of warlike stores; the supervision and control of the national armories; the issue of orders relating to military posts and operations; and the correspondence growing out of these various branches—all this pressure of business was sustained by the Secretary of War without other than clerical assistance previous to the year 1812[2]. In 1809 General Dearborn, "a man of vigorous mind, of extensive knowledge of detail, and of indefatigable industry," in going out of office as Secretary of War, declared "that the business of the Department had increased beyond what the capacity of any one man could perform, and that some aid and assistance was indispensable to the public service, whoever his successor might be."[3]

In 1812, after the augmentation of the army by the addition of 25,000 men had been directed, it became absolutely necessary to reorganize the War Department, so as to relieve the Secretary of War of the vast burden of details that pressed upon him.[4] It was accordingly proposed by the President that two additional officers be added to the War Department, to be denominated Assistant Secretaries of War.[5] But this proposition was opposed on the ground that measures already passed, or then pending, would obviate the creation of these additional offices.[6] These measures were the establishment of a Quartermaster-General's Department, a Purchasing Department, and an Ordnance Department, which, with the Medical Department, Paymaster-General, Adjutant-General, Inspector-General, &c., already provided, would diminish in a very considerable degree the labors of the Secretary of War. These several departments were accordingly established in 1812,[7] with a chief officer in each, and a corps of deputies and assistants as auxiliaries in the various military districts then organized.

It was made the duty of the Quartermaster-General and his deputies and assistant deputies, when thereto directed by the *Secretary of War*, to "purchase military stores, camp equipage, and other articles requisite for the troops, and generally to procure and provide means of transport for the army, its stores, artillery, and camp equipage"; and the offices of the military agents were abolished.[8]

It was made the duty of the Commissary-General of Purchases and his deputies, under the direction and supervision of the *Secretary of*

[1] Am. Stat. Pap. Mil. Aff., vol. 1, *passim*.
[2] Annals of Cong., Twelfth Congress, part 5, 1811–'12, p. 1362.
[3] Ibid., p. 1362.
[4] Ibid., pp. 1362–1365.
[5] Jour. H. R., April 20, 1812.
[6] Annuals of Cong., Twelfth Congress, part 2, 1811–'12, pp. 1362–1365.
[7] 2 Stat. Large, 696, 732.
[8] Ibid., p. 696.

War, to "conduct the procuring and providing of all arms, military stores, clothing, and generally all articles of supply requisite for the military service"; and the office of Purveyor of Public Supplies was abolished.[1]

In 1813[2] the *Secretary of War* was directed by law to "define and prescribe the species, as well as the amount, of supplies to be respectively purchased by the Commissary-General's and Quartermaster-General's Department, and the respective duties and powers of the said departments respecting such purchases."

It was made the duty of the Commissary-General of Ordnance, in 1812, to direct the inspection and proving of all ordnance, cannon-balls, shells, and shot; to direct the construction of all carriages, &c., for garrison and field service, and all ammunition wagons, traveling forges, &c.; also the direction of laboratories, the inspection of powder, and the preparation of ammunition.

The law creating the Purchasing Department permitted the commanding general of the forces, the Quartermaster-General, and the deputy quartermasters to direct the deputy commissaries of purchases, "in *cases of necessity*," to make purchases of articles needed by the troops; and the law creating the Ordnance Department directed the officers of that department to execute faithfully and without delay, "*in time of war*," the orders issued by the commanding officer of corps, camps, or garrisons for the supply of ordnance, ammunition, &c. In the absence of these emergent occasions, commanding officers of troops of the line had no authority over these departments, the jurisdiction of the Secretary of War being exclusive and supreme.

It will thus be seen that in the war of 1812 the functions of the Secretary of War in regard to purchases and contracts for military supplies of every description in the Quartermaster and Purchasing Departments, and the construction of gun-carriages, preparation of ammunition, &c., in the Ordnance Department, had come to be exercised through a new set of agencies, placed directly under his supervision and control. The officers of the army in command of troops of the line were given no further control over these departments than that specified in the laws, viz, in cases of "necessity" to direct purchases to be made, and in time of actual "war" to command their troops to be supplied with ordnance and ordnance stores.

The act of March 3, 1813,[3] authorized the *Secretary of War* to "prepare general regulations, better defining and prescribing the respective duties and powers of the several officers in the Adjutant-General, Inspector-General, Quartermaster-General, and Commissary of Ordnance Departments, of the topographical engineers, of the aids of generals, and generally of the general and regimental staff, which regulations, when approved by the President of the United States, shall be respected and obeyed until altered or revoked by the same authority." This act also provided for a Physican and Surgeon-General and an Apothecary-

[1] 2 Stat. Large, p. 696. [2] Ibid., p. 816. [3] Ibid., p. 819.

General for the Medical Department of the army, whose respective duties were to be prescribed by the President.

Six major-generals and sixteen brigadier generals were appointed for the war of 1812. The country was divided into nine military districts, commanded by general officers, each of whom was supplied with the proper number of staff officers.[1] The senior major-general commanding the main army was entitled to a private secretary; the Ordnance and other departments of supply in the various districts were subject, of course, under the existing laws, to the orders of the generals commanding during the period of the war; all orders from the President relating to military operations were communicated by the Secretary of War direct to the commanding generals, and orders to subordinate officers passed from the War Department to the Adjutant-General, to be communicated by him to the general commanding the district in which such subordinate officers might be serving.[2]

By act of February 8, 1815,[3] the national armories were placed under the Ordnance Department, this department being placed by this act entirely under the supervision and control of the *Secretary of War* in all its details. Officers in command of troops of the line were, however, still authorized to draw, *in time of war*, supplies of ordnance stores, without awaiting the permission of the Secretary of War.

Two branches—the one for securing proper accountability for *public moneys* disbursed by officers, agents, and other persons for the benefit of the military establishment; the other for securing accountability for *property* in store or in the hands of troops—were established in the War Department in 1792[4] and 1794[5] respectively.

The audit and settlement of money accounts were intrusted to the accountant of the War Department, under the direction of the Secretary of War in 1792; and in 1794 a Superintendent of Military Stores was authorized, whose duty it was, "under the direction of the Department of War, to superintend the receiving, safe-keeping, and distribution of the military stores of the United States, and to call to account all persons to whom the same may be intrusted." By act of March 3, 1813,[6] this latter office was abolished in terms, and a Superintendent-General of Military Supplies was authorized, who was to reside at the seat of Government, and, under the direction of the Secretary of War, "to keep proper accounts of all the military stores and supplies of every description purchased or distributed for the use of the army of the United States, and of the volunteers and militia in their service; to prescribe the forms of all the returns and accounts of such stores and supplies purchased, on hand, distributed, used, or sold, to be rendered by the Commissary-[General] of Ordnance and officers in his Department, by the Commissary-General of Purchases and his deputies, by the several officers in the Quartermaster-General's Department, by the regimental

[1] Am. State Pap., Mil. Aff., vol. 1, p. 385.
[2] Ibid., p. 465.
[3] 3 Stat. Large, 203.
[4] 1 Stat. Large, 279.
[5] Ibid., 352.
[6] 2 Stat. Large, 816.

quartermasters, by the hospital surgeons and other officers belonging to the Hospital and Medical Departments, and by all other officers, agents, or persons who shall have received, distributed, or been intrusted with such stores and supplies as aforesaid; to call to account all such persons; to audit and settle all such accounts, and, in case of delinquency, to transmit the account, and to state the value of the articles unaccounted for by such delinquency to the accounting officers of the Treasury for final settlement and recovery of such value; to transmit all such orders, and generally to perform all such other duties respecting the general superintendence of the purchase, transportation, safe-keeping, and accountability of military supplies and stores as aforesaid, as may be prescribed by the Secretary for the War Department." All the heads of the great supply departments—the Purchasing Department, the Quartermaster's Department, the Ordnance Department, the Medical Department—and all the subordinate officers of these Departments, and all officers, agents, or persons intrusted with military stores of any description whatever, whether in store or for the regular army, or for volunteers or militia in service, were required to render quarterly returns to the Superintendent-General of Military Supplies for audit and settlement.

In the same manner quarterly accounts of all moneys received in advance from the War Department were required to be rendered to the accountant of the War Department; and the accounts for property and for money were required by the act of 1813 to be settled by the superintendent and the accountant within three months after receipt at their respective offices.

By act of March 3, 1817,[1] however, the money and property branches of the War Department were both abolished, and it was enacted that after the 3d of March next "all claims and demands whatever, by the United States or against them, and all accounts whatever in which the United States are concerned, either as debtors or as creditors, shall be settled and adjusted in the Treasury Department." To provide for this augmentation of the duties of the Treasury Department, one Comptroller and four Auditors were added to that Department. The accounts emanating from the War Department were directed to be audited by the Second and Third Auditors. It was made the duty of the Second Auditor to receive not only the "accounts relative to the pay and clothing of the Army, the subsistence of officers, bounties, and premiums, and the contingent expenses of the War Department," but also the accounts relative to "military and hospital stores"; while the Third Auditor was to "receive all accounts relative to the subsistence of the Army, the Quartermaster's Department, and generally all accounts of the War Department other than those provided for."[2]

[1] 3 Stat. Large, 366.

[2] This enlargement of the functions of the Treasury Department was made upon a joint report of the Secretaries of the several Executive Departments made to the

THE ORGANIZATION OF THE WAR DEPARTMENT IN 1818.

After the close of the war, March 3, 1815,[1] an act was passed reducing the Military Establishment to a peace basis. It provided for two major-generals and four brigadiers, and such portions of artillery, infantry, and riflemen, not exceeding ten thousand men, as the President might deem proper; also the corps of engineers as then established. The two major-generals were given separate independent commands, denominated the Northern and Southern Division, respectively—the former commanded by Maj. Gen. Jacob Brown and the latter by Maj. Gen. Andrew Jackson.[2]

It had been a great object of the English House of Commons for a considerable portion of the last century to fix upon the Secretary at War in that country a plain and definite parliamentary responsibility in connection with the monetary affairs of the British military service.[3] The ambiguity of his position in respect to the active army arose out of the form of his appointment, which, being military in character, the Commander-in-Chief of the British forces was enabled to use the words of the Secretary's commission to show his superiority over him, and to supersede the financial and parliamentary functions bestowed on the latter in control of military expenditures.[4] The official duties of the office of Commander-in-Chief were totally undefined, and the Duke of York, succeeding to the office in 1795, fell into the mistake of supposing, as Lord Palmerston subsequently expressed it,[5] that "the whole and absolute control over every part of the military service was vested in the Commander-in-Chief." The proper relationship which should exist

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Senate December 9, 1816, in obedience to a resolution of that body of April 20, 1816. This report recommended the abolition of the offices of Accountants for the War and Navy Departments, and also that of Superintendent-General of Military Supplies. Said they, in explanation of their plan: "Both of these Auditors [the Second and Third] will keep the property account connected with those branches of service in the War Department confided to them respectively." (See their report in Annals of Congress, second session, Fourteenth Congress, 1816–1817, pp. 23 to 30.) The Third Auditor still retains the settlement of accounts for clothing and quartermaster's stores; and the Second Auditor performed that function in respect to ordnance stores until December, 1870, when, by a Departmental order of the Secretary of War, the further forwarding of property returns of ordnance to that officer was suppressed. No change by legislation has been made in the duties of the Auditors and Comptrollers in respect to Army accounts, for either money or property, since 1817. The existing provisions of the Revised Statutes are taken directly from the act of March 3, 1817. In 1877, by an amendment to section 1667, Revised Statutes, all returns of ordnance stores were required to be rendered to the Chief of Ordnance; and the Secretary of War has decided that the Chief of Ordnance, under that amendment, is authorized to audit and settle them.

[1] 3 Stat. Large, 224.

[2] Am. State Pap., Mil. Aff., vol. 1, p. 627.

[3] Clode's Mil. Forces of the Crown, vol. 2, p. 262.

[4] Ibid., p. 264.

[5] Ibid., p. 339.

between the Secretary at War and the Commander-in-Chief was not settled until Lord Palmerston entered upon the former office in 1809, and continued in it until 1828. As soon as he began to take a course in matters of finance in opposition to the Commander-in-Chief, a controversy, of course, at once arose, which was ultimately settled by royal warrant of May 12, 1812,[1] whereby the constitutional doctrine that all army expenditures should rest upon the decision of the civil minister responsible to Parliament was permanently established; for, as had been said, "to allow the army to determine the amount of its own expenditures would be to terminate all civil government."

Said the Duke of Wellington, in 1828,[2] in answer to a question whether the executive duties of the Commander-in-Chief and the administrative duties of the Secretary at War could not be thrown together in one office with advantage to the public service:

I should earnestly recommend that it should not be adopted; the Commander-in-Chief's office is entirely disconnected with money; the Commander-in-Chief has no power of giving an allowance to anybody, or of incurring any expense whatever. * * * Considering who the persons are who are likely to be Commanders-in-Chief of the troops in this country, I do not think it would be an economical arrangement to put the power of incurring expense into their hands, instead of keeping that power in the hands of the Secretary at War, who must answer to Parliament for every expense incurred. It is much better the Secretary at War should be the person to regulate that matter than that it should be in the hands of officers connected with the army. In former times the Secretary at War was, in fact, the Secretary of the Commander-in-Chief, and of course he was obliged to obey the commands of the Commander-in-Chief. Owing to different circumstances, he is no longer in that situation; he is an officer responsible himself for certain duties, and in fact he is a check on the Commander-in-Chief for the object of economy.

And on another occasion he said:

The Secretary at War has a clear, simple duty to perform—he has to take care that the votes of Parliament are not exceeded, and that no expense is incurred by the Commander-in-Chief which is not necessary; in short, that no expense can be incurred without his consent.

This principle of ministerial control over military expenditures will be seen to be identical with the current of legislation and of public sentiment in our own country, from 1785 to the period of which we are hereafter to treat, when the principle received a systematic application in the reorganization of the War Department which then took place.

No sooner had the excitement attending the French difficulties of 1798 subsided than the regular army was reduced to 2,739 officers and men,[3] scarcely enough for protection from the Indians. Meanwhile the Government was steadily working out the construction of sea-coast fortifications, and the erection and operation of arsenals and armories. These, being works of permanent preparation and defense, were all carried on under the direction of the civil Minister of War. When the war of 1812 had arrived, requiring the placing of *men* in large numbers in the field,

[1] Clode's Mil. Forces of the Crown, vol. 2, p. 265.
[2] Ibid, p. 270.
[3] Am. State Pap., Mil. Aff., vol. 1, p. 670.

these preparations were availed of, but the *personnel* engaged in them were at the beginning of that war given a military character; and Congress, in its desire to rid the country of the standing army left in commission at the close of the war, came well-nigh destroying, by an act of hasty legislation,[1] the entire structure of administration that had been created for the purpose of affording relief to the civil office of Secretary of War. By provisionally retaining some of the branches, and inviting the attention of Congress to the matter, the whole structure was eventually restored, and within a few years thereafter a degree of efficiency in the War Office and in army adminstration had been attained superior to any that had existed before.

The views of the civil minister under whom this restoration took place (Hon. John C. Calhoun) are well worthy of insertion here, for the scheme of administration which he inaugurated has remained essentially the same to the present day. Grasping the whole doctrine of ministerial control over the military expenditures of the State, he constructed, out of the materials afforded him by the laws restoring the "Staff of the Army," a system of departmental or bureau administration which has been productive of the most beneficial results, and has received the high distinction of being since copied in other services. The system is applicable to both peace and war, and is the basis of all military efficiency coupled with ministerial control in all armies that may be raised by authority of the United States, whether regulars, volunteers, or militia. With this system the regular or standing army may be reduced or increased to any number consistent with the actual needs of the country; with it the volunteers or militia may be called into active service at any time. It is sufficiently identified with "the army" (the coercive power of the State) to preserve a proper military *esprit* in its processes of administration; it is sufficiently removed from "the army" to preserve an independent administrative control, under the supervision and direction of the civil Minister of War, over military funds, property, and industrial operations connected with the warlike preparations of the country.

The sentiment in Congress, for several years after the close of the war of 1812, for reducing the officers and troops in service to a minimum consistent with the actual requirements of the public service and the monetary depression of the times, was strong and irresistible.[2] The Secretary of War (Hon. John C. Calhoun), being called upon by the House of Representatives, in 1818, for a report on the reduction that could be made in the establishment as then organized, made an elaborate report upon the subject, in which he treated of the "staff" as follows:[3]

The staff, as organized by the act of last session, combines simplicity with efficiency, and is considered to be superior to that of the periods [1802 and 1808] to which I

[1] 3 Stat. Large, 224; Gordon's Compilation of Army Registers, 1837, pp. 51 to 60.

[2] Annals of Cong., 1815 to 1820, *passim*.

[3] Am. State Pap., Mil. Aff., vol. 1, p. 780.

have reference. In estimating the expenses of the army, and particularly that of the staff, the two most expensive branches of it (the Engineer and Ordnance Departments) ought not fairly to be included. Their duties are connected with the permanent preparation and defense of the country, and have so little reference to the existing military establishment, that if the army were reduced to a single regiment, no reduction could safely be made in either of them. To form a correct estimate of the duties of the other branches of the staff, and consequently the number of officers required, we must take into consideration not only the number of troops, but what is equally essential, the number of posts and extent of country which they occupy. Were our Military Establishment reduced one-half, it is obvious that if the same posts continue to be occupied which now are, the same number of officers in the Quartermaster's, Commissary's, Paymaster's, Medical, and Adjutant and Inspector General's Departments would be required. To compare, then, as is sometimes done, our staff with those of European armies assembled in large bodies, is manifestly unfair. The act of last session, it is believed, has made all the reduction which ought to be attempted. It has rendered the staff efficient, without making it expensive. Such a staff is not only indispensable to the efficiency of the army, but is also necessary to a proper economy in its disbursements; and should an attempt be made at retrenchment, by reducing the present number, it would, in its consequences, probably prove wasteful and extravagant. In fact, *no part of our military organization requires more attention in peace than the general staff.* It is in every service invariably the last in attaining perfection; and, if neglected in *peace*, when there is leisure, it will be impossible, in the midst of the *hurry and bustle of war*, to bring it to perfection. It is in peace that it should receive a perfect organization, and that the officers should be trained to method and punctuality; so that, at the commencement of a war, instead of creating anew, nothing more should be necessary than to give to it the necessary enlargement. In this country, particularly, the staff cannot be neglected with impunity. Difficult as its operations are in actual service everywhere, it has here to encounter great and peculiar impediments, from the extent of the country, the badness and frequently the want of roads, and the sudden and unexpected calls which are often made on the militia. If it could be shown that the staff, in its present extent, was not necessary in peace, it would, with the view taken, be unwise to lop off any of its branches which would be necessary in actual service. With a defective staff, we must carry on our military operations under great disadvantages, and be exposed, particularly at the commencement of a war, to great losses, embarrassment, and disasters. * * *

It only remains to consider, in relation to this part of the resolution of the House, whether the expense of our military establishment can be reduced by a proper attention to its administration, or by a more rigid enforcement of responsibility and economy. Our military establishment is doubtless susceptible of great improvement in its administration. The field is extensive, and the attention of the Government has not heretofore been so strongly directed towards it as its importance deserves. Here all savings are real gain, not only in a moneyed, but a moral and political point of view. An inefficient administration, without economy or responsibilty, not only exhausts the public resources, but strongly tends to contaminate the moral and political principles of the officers who are charged with the disbursements of the army. To introduce, however, a high state of economy and responsibility in the management of a subject so extensive and complicated as our military establishment, is a task of great difficulty, and requires not only a perfect organization of the Department charged with it, but a continued, energetic, and judicious enforcement of the laws and regulations established for its government. The organization is the proper sphere of legislation, as the application of the laws and regulations is that of administration. The former has done all, or nearly all, that can be done.

It is believed that the organization of the War Department, as well as the general staff of the army, is not susceptible of much improvement. The act of the last ses-

sion, regulating the staff, has not only made important savings in the expenses of the army, but has given both to the Department and the staff a much more efficient organization than they ever before had. Every department of the army charged with disbursements has now a proper head, who, under the laws and regulations, is responsible for its administration. The head of the Department is thus freed from detail, and has leisure to inspect and control the whole of the disbursements. Much time and reflection will be required to bring the system into complete operation, and to derive from it all the advantages which ought to be expected. The extent of the saving which may result from it can only be ascertained by time and experience; but, with an attentive and vigorous administration, it doubtless will be considerable. In war, it will be much more difficult to enforce economy and responsibility; but, with a system well organized, and with officers trained to method and punctuality, much of the waste and frauds which would otherwise take place in war will be prevented. In peace, there can be no insuperable difficulty in attaining a high degree of responsibility and economy. The mere moneyed responsibility, or that of purchases and disbursements, will be easily enforced. The public now sustain much greater losses in the waste and improper use of public property than in their moneyed transactions. In our military establishment, responsibility in the latter is well checked, and not badly enforced. The accounts are rendered with considerable punctuality, and are promptly settled; and even neglect or misapplication of public funds by the disbursing officers is not often accompanied with ultimate losses, as they are under bonds for the faithful discharge of their duties. Accountability, as it regards the public property, is much more difficult, and has heretofore been much less complete. Returns of property in many cases, particularly in the Medical Department, have rarely been required; and even where they have been, they have not been made with punctuality. It cannot be doubted but that the public have sustained very considerable damage from this want of accountability. Every article of public property, even the smallest, ought, if possible, to be in charge of some person who should be responsible for it. It will be difficult to attain this degree of perfection; but it is hoped, by making each of the subordinate departments of the War Department liable for the property in its charge, a very considerable improvement and reduction of expenses will be made.

Intrusted as most of the staff departments were by law with the purchase, preservation, and issue of military supplies, and each of them forming a convenient channel for administering to the wants of the "army," the several heads of these departments were called to Washington by Mr. Calhoun in 1818, with such assistants as the duties required, and were formed into bureaus or sub-departments of the War Department. This bureau organization became in time a matter of fixed determination, and in section 5 of act of July 4, 1836,[1] it received direct legislative recognition.

The further curtailment of the Military Establishment being, however, insisted upon by Congress in 1820, the Secretary of War (Hon. John C. Calhoun) in that year made a farther report[2] to the House, in which he said:

The organization of the staff in a peace establishment ought to be such that every branch of it should be completely formed, with such extension as the number of troops and posts occupied may render necessary. * * *

It is believed that the true principle of its organization is, that every distinct branch of the staff should terminate in a chief, to be stationed, at least in peace, near the seat of Government, and to be made responsible for its condition. It is thus that the

[1] 5 Stat. Large, 117. [2] Am. State Pap., Mil. Aff., vol. 2, pp. 189–192.

Government may at all times obtain correct knowledge of the condition of the army in every particular, and be enabled to introduce method, order, and economy in its disbursements. It is at present, with slight exceptions, thus organized, and the beneficial effects of it have already been strikingly exemplified by experience.

In 1822,[1] referring to this organization of his Department, he said:

The present organization originated in the act of Congress of April 14, 1818, and has been long enough in operation to be tested by experience; and though it has not yet attained, in its operation, all of the perfection of which it is susceptible, yet it is believed that under no other system has there been greater punctuality in rendering and settlement of accounts or economy of disbursements of the Department. The Committee will have a full view of the present system and its operations by reference to the regulations of the army, a copy of which I herewith transmit. They will perceive that the regulations propose to carry a minute and rigid responsibility in every branch of military disbursements—with what success a reference to the expenditures under their operation will best illustrate. The Committee will perceive, by referring to the regulations, that one principle pervades the whole organization—to hold the head of each subordinate department responsible for the disbursements of his department. All advances are made on his recommendation, founded on precise estimates; and *all accounts are rendered to him, and, before they are audited, are minutely examined by him and approved.* It is thus that responsibility is extended to every item of disbursements, and regularity and economy introduced.

That this arrangement met with the full concurrence and approbation of the President—the supreme Civil Magistrate and Commander-in-Chief of the army—let the following extract from his annual message of December 3, 1822, attest:

With the organization of the staff there is equal cause to be satisfied. By the concentration of every branch with its chief in this city, in the presence of the Department, and with a grade in the chief military station to keep alive and cherish a military spirit, the greatest promptitude in the execution of orders, with the greatest economy and efficiency, are secured.

Regular annual appropriations are made for the maintenance of an organized clerical force in the office of each of these chiefs of bureaus, and this force is placed, in all respects as to grade, and pay, and tenure of office, upon the same footing as the clerical forces in the other great Executive Departments at Washington.[2]

The army regulations adopted about this period bore out, to the minutest details, the theory of organization here set forth.[3] The supervisory jurisdiction and executive control of the Secretary of War over certain affairs of the staff corps and departments, through the chiefs stationed in Washington, and to the exclusion of officers in command of troops of the line, were fully amplified and explained. The matter of relative military rank between staff and combatant officers was also settled and adjusted by these regulations, which, as a whole, formed a harmonious compend for the systematic and orderly government of the Military Establishment, having respect to that feature for which the House of Commons in England had so long striven—viz.: ministerial

[1] Am. State Pap., Mil. Aff., vol. 2, p. 345.

[2] Rev. Stat., Title IV, pp. 26 to 31; Title VI, pp. 35 to 37.

[3] Army Regulations, 1825 and 1835-'36.

supervision and control. This control, when traced out to its ultimate applications in our service, will be found to pervade the whole "MILITARY ESTABLISHMENT" of the nation; and by this term, as herein used, is meant the whole organized Executive Department of Government, charged, in general and in detail, with the development of the war power of the country, and the maintenance, government, support, and direction, for the purposes of government, of the combatant body of men denominated the army (whether regulars, volunteers, or militia), and of permanent works, operations, and business in connection therewith. The term thus defined includes at the present day, in *matèriel and personnel*, the following:

1. The fortifications of the country, those in process of construction as well as those in the completed state (the latter are turned over to the custody of the army proper), torpedo defenses, and works of river and harbor improvements, surveys, &c.

2. The arsenals for the storage, construction, and repair of arms and munitions of war, their appendant magazines, the national armory; at each of which places military stores are provided in bulk to meet the current wants of the service, and preserved to meet the contingency of war.

3. The permanent depots for the purchase, storage, and distribution of clothing, camp and garrison equipage, means of transportation, forage, &c.

4. The permanent depots for the purchase and distribution of provisions to the army.

5. The permanent hospital accommodations and medical stores in connection therewith.

6. The signal service, and the stores in connection therewith.

7. A repository in the War Department of the records of the *personnel* of the entire Military Establishment, superintendent of recruiting, and an organ for the promulgation of the military orders of the President and Secretary of War, and of the senior general of the army when assigned to duty as "commanding the army."

8. A repository in the War Department of all records of military trials.

9. The Military Academy.

The most of these branches of the Military Establishment are objects of large appropriations of money by Congress, and each is supplied with a special *personnel* of officers, or officers and enlisted men, upon whom the discipline of the military is imposed in aid of a proper administration. The Military Academy is supplied in part by details of officers from the army and the staff departments. In some of these branches large forces of civilian experts, mechanics, artisans, and laborers are engaged, and large contracts entered into, and other mercantile transactions had, with the non-military world, constituting a train of ordinary duties not entirely of a military character, to which the term *civico-*

military has been applied. In some of them the duties require high scientific and professional attainments, necessitating a life-long devotion to special pursuits. Excluding the Military Academy, these several branches are conventionally termed "staff corps," "bureaus," or "departments," and are enumerated as follows: 1st, Engineer's; 2d, Ordnance; 3d, Quartermaster's; 4th, Subsistence; 5th, Medical; 6th, Signal Service; 7th, Military Justice. To these may also be added the Adjutant-General and the Inspectors-General of the army, who are stationed in the War Department as adjuncts to the Secretary of War and staff officers of the commanding general.

In a pure democracy, such as ours, where the innate aggressiveness of standing armies affords a well-grounded prejudice against them in the minds of the people, and where (the Government being erected "*by* the people and *for* the people") each able-bodied citizen is, of and within himself, a potential soldier for the defense of the State, it is obvious that some governmental organization, such as these staff corps and departments afford, must constitute the substructure upon which our military efficiency as a nation must depend. With a view to a ready development of national strength when occasion may require, the maintenance of most of these corps and departments during peace is essential, whether we have a single soldier in the field at any given time or not. It is through their labors in peace, and activity in war, that the efficiency of our citizen soldiery, or raw combatants, must largely depend. Were the object of popular jealousy (the armed body of men denominated "*the army*") to be entirely disbanded, the necessity for maintaining these permanent works, manufactories, and depositories, with their appropriate retinues of officers and men for their care, preservation, and operation, and of officers needful for preserving the intricate knowledge of military administration, would still remain. This much, at least, of warlike preparation must be maintained to aid in suppression of casual domestic contentions at home, and to preserve us from domination from abroad. Relying as we must, and always have, upon the volunteers and militia as our chief defense, an army called into the field without the aid which these preparations afford would be sadly lacking in the most vital elements of military efficiency. No army, either regular, volunteer, or militia can exist in the same degree of vigor without them; but *they* can exist with perfect safety to the liberties of the people, and with advantage to them, without a single armed soldier in the field. In their organized official capacities they are permanent governmental institutions of which all armies raised are the beneficiaries.

10. The army, therefore (or armies), is the element which completes the Military Establishment, and which, together with the navy, forms the immediate and active coercive power of the State. Webster's Dictionary defines an army to be "a collection or body of men armed for war and organized into companies, battalions, regiments, brigades, and

divisions under proper officers." Halleck (*Elements of the Military*, p. 235) says:

> By the law of the 12th of December, 1790, on the organization of the public force of France, the army was defined "a standing force drawn from the public force and designed to act against external enemies." (*Une force habituelle extraite de la force publique, et destinée essentiellement à agir contre les ennemis du dehors.*) In time of peace the whole organized military force of the State is intended when we speak of the *army;* but in time of war this force is broken up into two or more fractions, each of which is called an army.

With us a minimum military force is always kept on foot in time of peace, and this "collection, or body of men," or "standing force," is called the Regular Army in contradistinction to the volunteers and militia, the latter of whom, by our great charter of liberty, are proclaimed to be "necessary to the security of a free State." It is for the benefit of these latter, therefore, as well as the former, that all warlike preparations by the Government should be made.

Composed of general officers and aides, regimental officers, company officers, non-commissioned officers, and men, armed and equipped under the three principal arms of artillery, cavalry, and infantry, our "armies" are at all times possessed of the completed fortifications, and are assisted by officers and men of the staff corps and departments detailed by the Secretary of War for duty with them, provided in all needful cases, by his direction, with public funds and property to be expended under the directions of the commanding generals according as the exigencies of the particular military operations, sanctioned by the Government, may require.

The wisdom of our British ancestors is written in our Constitution, wherein it is prescribed to Congress that no appropriation to the use of the army shall be made for a longer term than two years; and the Congress has provided that moneys to this use shall be drawn from the Treasury (not by the commanding officer of the troops, but) by a great civil officer of State, who, standing between the army and other portions of the Military Establishment and the public Treasury, is the "constitutional organ of the President for the administration of the Military Establishment of the nation,"[1] and as such is the guardian of the civil Government against unlawful encroachments of the military power. Through the bureaus of his Department strict accountability is rendered to the great civil Department of the Treasury for the funds disbursed under his direction or by his approval. Representing the supreme Civil Magistrate, he is no part of the army and has no duties to perform in the field. At the head of his Department, he is amenable to no military jurisdiction whatever, and no military man is his official peer. He cannot submit to be overborne by military personages in any contest for the exercise of prerogatives lawfully inhering in his office. He is answerable to the President and the law for the faithful discharge of the trusts reposed in his hands.

[1] United States *vs.* Eliason, 16 Peters, 291, and Wilcox *vs.* Jackson, 13 Peters, 498.

The staff corps, bureaus, and departments having become permanent organized agencies, under the control of the Secretary of War, for the administration of certain matters pertaining to the military affairs of the nation, their duties may be classified under two designations, viz, "sedentary duties" and "active military duties."

The sedentary duties are performed within the limits and special jurisdictions of the bureaus, corps, and departments themselves, and are by the creative laws under the direction and control of the Secretary of War. The official *personnel* of these several branches, being made subject to the military law and discipline, invested with military rank, and made liable to perform duty under the commanding officers of the combatant forces, are called portions of the *army*. But military rank and titles were not at first conferred on all these branches, and were only finally conferred in order to promote military respect appropriate to the importance of the duties performed when the officers of these branches were thrown in intimate personal and official relationship with the officers of the active army proper; the rank thus given, however, is of a limited kind; the officers of the Pay and Medical Departments being rendered totally ineligible to command outside of their respective departments, and the officers of the other branches are eligible to the command of officers and troops of the line of the army only upon special assignment by the President for the purpose. As the officers of these branches are by law permitted no inherent right to command officers and troops of the combatant army by reason of their military commissions, so the combatant officers of the army in respect to the sedentary duties of these branches, which are under the direction of the Secretary of War exclusively, are equally excluded from intrusion by way of command except only as permitted by law in time of war or of pressing military emergency.

These sedentary duties, aside from their scientific or professional character, constitute the organized administrative system for the planning and erection of fortifications which the army is to man and defend; for the collection and preservation of exact historical records, &c., of the Military Establishment; for the procurement, manufacture, preservation, and distribution of the vast quantities of warlike materials destined for the use of the army or armies of the nation; and for the application of the enormous sums appropriated by Congress for the support of the Military Establishment in all its branches of service. Congress appropriates specifically for the items which make up these enormous amounts, and directs the moneys to be drawn from the Treasury by requisitions of the Secretary of War, to be expended under his direction, he being the actual responsible officer to the law and to the country for the proper administration of the affairs of the Military Establishment. For examples of duties of this sedentary character, those of the Chief of Engineers and all other engineer officers who are not detached from their ordinary duties and assigned to the active army proper, may be

referred to; so those of the Chief of Ordnance and officers of the Ordnance Department not assigned as above; so those of the Quartermaster-General and assistants in his office, and the Deputy Quartermasters-General in charge of permanent depots of quartermaster's supplies where purchases are made in bulk, by direction of the Secretary of War, for storage as reserve supplies, or for distribution to subordinate depots with the army, &c.; so those of the Commissary-General of Subsistence, and officers of the Subsistence Department not assigned to the army proper; so those of the Surgeon-General and officers of the Medical Department not so assigned; so those of the Paymaster-General, &c.; the Chief Signal Officer; the Judge-Advocate-General; and the Inspectors-General and Adjutant-General, when acting in connection with the office of the Secretary of War.

The "active military duties" are performed when the officers of these branches are detached by the Secretary of War from their sedentary duties and assigned to duty with any troops under the command of combatant officers of the army. They are usually assigned to duty on the staffs of general officers, and to the discharge of other appropriate active duty with the army proper, where their complete knowledge of administration in their respective branches (in channels leading up through the chiefs of their branches to the Secretary of War) renders them invaluable as adjuncts to the active military forces. For examples of duties of this character, those of the officers of the several branches who are doing duty under the command of combatant officers of the army may be referred to. When thus assigned they are *de facto* and *de jure* subject to the entire jurisdiction of the army officer commanding them, to the full extent to which the laws, regulations, and customs of service may give authority in the premises.

The *personnel* of most of these subordinate branches is made up by transfers from the active army in the lower grades, and by subsequent promotions in regular gradation as vacancies occur.

It will hence be seen that by the system thus established the active army has been always supplied with competent staff officers, and the Secretary of War has been aided in the sedentary duties of the several branches by corps of professional and scientific experts in all matters relating to the national defense and the wants of the living army, and who, having restricted rank and being subject to the rigors of military law, are spread as a net-work over the country, as accountants and professional ministerial officers, having direct communication with, and rendering accountability to, him through the chiefs of the several bureaus of the War Department. The military funds and property are thus kept within the control of the civil government at Washington, to be applied or transferred from one section of the country to the other, as the exigencies of the service may require. In the cases of officers of those branches not intrusted with funds or property, the lines of communication from the army to the Secretary of War are kept up through

the chiefs of those branches respectively, in order that the War Department, as the great civil Executive Department for War, may be made and retained as the repository of the archives of every branch of the "*Military Establishment*," whereby the details of administration in respect to both *personnel* and *matèriel* may be kept continually under the eye of Government at the capital of the nation, not only for purposes of surveillance, but for historical evidence for use in all other branches of the Government—legislative, executive, and judicial.

THE COMMAND OF THE ARMY SINCE 1821.

In reducing the army, in 1821, Congress fixed the number of general officers at one major-general and two brigadiers.[1] The Secretary of War had already assembled around him as assistants the chiefs of the several bureaus, corps, and departments,[2] and in making his report to Congress in 1822 [3] (which it may be stated in passing, was the first of the series of *annual* reports that have been made by the Secretaries of War since that year), he states that in order to render the organization of the Military Establishment more complete he had stationed the major-general at the seat of Government, "thus bringing the *military* administration of the army, as well as its pecuniary, through the several subordinate branches, under the immediate inspection and control of the Government." The major-general in this and subsequent years made his report directly to the Secretary of War, as did the Chief of Engineers, the Colonel on Ordnance duty, the Quartermaster-General, the Paymaster-General, the Surgeon-General, the Commissaries-General of Provisions and Purchases, who are collectively denominated by the Secretary of War, in the above report, "subordinate branches." The "subordinate branches" then existing, and all similar ones since created, have invariably (except in 1869, a period hereinafter to be referred to) made their annual reports of operations and finance direct to the Secretary of War, under whom their operations are conducted, and not to or through the general officer assigned to the command of the army.

A vacancy by death having occurred in the office of major-general in February, 1828, the Military Committee of the Senate inquired into the expediency of abolishing the grade of major-general altogether from our service; but the Committee came to the conclusion that a general commanding was necessary as a "medium of communication between the Government and the army," and that if the office were abolished the functions of a general in command would remain to be in some manner performed; that if the Secretary of War was not by education a military person he would be without the requisite technical knowledge for the purpose, and hence would be controlled by the staff officers by which

[1] 3 Stat. Large, 615. [2] Am. State Pap,. Mil. Aff,. vol.2, p. 297, 420. [3] Ibid., p. 450.

he was surrounded.[1] The Secretary of War (Hon. P. B. Porter) expressed his views on the subject at the time as follows:[2]

My opinion, therefore, is that there should be at the head of the army of the United States—whether its numbers continue as at present, or whether they be enlarged or diminished—an individual higher in rank than any other officer, and who should have the immediate command of the whole; that he should be stationed, in times of peace at least, at the seat of Government, where he can most readily receive the advice and orders of the President, and where he can hold the most direct and expeditious communication with every part of his command.

The present organization being in conformity with the preceding views, it will readily be perceived that my opinion is against the expediency of abolishing the office of major-general. If it be said that the office of major-general being abolished, the army will then have a head in the President, or the Secretary of War, by whom his military functions are discharged, the answer is that the Department of War does not form an integral part of the military machine. The numerous civil avocations of the Secretary of War would put it wholly out of his power to attend to the daily orders and routine of duties which appertain to the command and discipline of an army; and the effect of a similar abolition of the office of major-general would, in the present state of the army, be to divide it into two separate, independent, and probably conflicting commands, under the two brigadiers, unless they should be connected through the instrumentality of the Adjutant-General, or some other subordinate officer stationed at the seat of Government, under the Secretary of War, and who would, in fact, perform the appropriate duty of the chief of the army.

For these reasons, therefore, the committee recommended the retention of the grade; and the command of the army, in the jurisdiction thus marked out, was accordingly exercised by an officer in the grade of major general until the year 1864, when the full grade of lieutenant-general[3] was revived, and in 1866[4] that of general, as we shall hereafter see. The brevet rank of lieutenant-general had been conferred on General Scott, the major-general, in 1855,[5] and he exercised the command in this brevet grade until November, 1861.[6] From this last date to 1864 the command was exercised by such major-generals as the President selected for the purpose.

General Scott, in 1821,[7] and afterwards in 1825, framed a system of regulations for the government of the army, in which no definitions of the duties of a general commanding the army were attempted. The major-general was called to Washington in 1821, as we have seen, in order that the military administration of the army might be brought under the inspection of the Secretary of War; and in 1828 it was determined to continue the grade of major-general, there being then two brigadier-generals in service. General Scott, in this latter year, laid some claim to recognition as the senior general officer of the army,

[1] State Pap., Senate, first session Twentieth Congress, vol. 4, doc. 144.
[2] State Pap., H. R., second session Twentieth Congress, vol. 3, doc. 119.
[3] 13 Stat. Large, 11.
[4] 14 Stat. Large, 333.
[5] 10 Stat. Large, 723.
[6] G. O. No. 94, A. G. O., 1861.
[7] Am. State Pap., Mil. Aff., vol. 2, p. 199.

and, writing to the Secretary of War on the subject, August 21, 1828, says:[1]

I do not claim the command of the army (under the President) as *positive* right. The acts of Congress in force do not create the office of "Commander-in-Chief," "General-in-Chief," or "Commander of the Army." The first and third offices existed in the Revolutionary War and in 1798-'99 respectively, and were both filled by the same individual—the Father of his Country. The existing laws do not even require that the senior general should be called to Washington to *act* as commander of the Army, &c., under the President. So before 1808, when we had but one general officer (Brigadier Wilkinson), he was not, but for a short period, charged with the immediate command of the army, but generally commanded a particular department or district whilst other departments or districts were placed under colonels. In 1808 two other brigadiers (Hampton and Gansevoort) were added to the establishment, and each of the three charged with separate geographical commands. The same arrangement prevailed throughout the late war, and again on the peace establishment, down to 1821. During all these periods the President held the immediate command of the army (through the War Department) in his own hands. In 1821, for the first time since the death of General Washington, the senior general (Brown) was charged with the command of the entire army, and called to Washington. It is, therefore, perfectly competent to the President to resume the immediate command of the army, through the War Department or otherwise, and to assign the several general officers of the line to separate geographical commands. All that I contend for, then, is this: if either of these generals be charged with the entire command of the army under the President, it must be the senior general on duty, which senior I am, &c.

In September, 1835, an edition of Army Regulations was issued from the War Department, which was amended and promulgated December 31, 1836, in which the following article occurred:

ARTICLE XXXIX.—THE COMMANDER OF THE ARMY.

1. The Military Establishment is placed under the orders of the major-general commanding-in-chief in all that regards its discipline and military control. Its fiscal arrangements properly belong to the administrative departments of the staff and to the Treasury Department, under the direction of the Secretary of War. While the General-in-Chief will not interfere with the concerns of the Treasury, he will see that the estimates for the military service[2] are based upon proper data, and made for the objects contemplated by law, and necessary to the due support and useful employment of the army. The general will watch over the economy of the service in all that relates to the expenditures of money, supply of arms, ordnance and ordnance stores, clothing, equipments, camp equipage, medical and hospital stores, barracks, quarters, transportation, fortifications, military academy, pay and subsistence; in short, everything which enters into the expenses of the Military Establishment, whether *personal* or *material*.[3] In carrying into effect these important duties, he will call to his council and assistance the staff[4] and those officers proper, in his opinion, to be employed in verifying and inspecting all the objects which may require attention. The rules

[1] Fry's Brevets, p. 105.

[2] Meaning the estimates on the War Department for supplying the local wants of the various portions of the combatant forces under the command of the general.

[3] Meaning a surveillance over the moneys and materials supplied by the War Department for application to the local wants of the various portions of the combatant forces under the command of the general.

[4] Meaning the officers of the staff departments assigned to duty with the combatant forces under the command of the general.

and regulations established for the government of the army and the laws relating to the military establishment, are the guides for the commanding general in the performance of his duties.

In this same edition, the functions of the several branches of the staff are thus comprehensively stated.

Adjutant General.—The Adjutant-General is the channel through which are issued all orders emanating from the headquarters of the army, and all regulations necessary to be communicated to the troops. He is charged with the details of the service, with the records of all military appointments, promotions, resignations, deaths, and other casualties, as well as the inventories of the effects of deceased officers and soldiers; with the registry, making out and distribution of all commissions of the army; * * * with the safe-keeping of the monthly returns of regiments and posts and muster-rolls of companies; the annual returns of the militia; * * * the records of the War Department which relate to the *personnel* of the army; with the duties connected with the recruiting service, and enrollment of all enlisted soldiers, &c. * * *

Inspector's Department.—It is through this Department that the Secretary of War and the commanding general are to be made acquainted with the actual state and condition of the army, and more especially the character and efficiency of the officers. * * *

Quartermaster's Department.—The Quartermaster-General is stationed at the city of Washington, and, under the direction of the Secretary of War, is charged with the military and administrative details of his Department. He has a complete administrative control of all the officers belonging to his Department, as well as those appointed to act therein or make disbursements on account thereof. * * * The objects of this Department are to insure an efficient system of supply, and to give facility and effect to the movements and operations of the army, &c. * * *

Engineer Department.—T Chief of the Corps of Engineers shall be stationed at the seat of Government, and shall be charged with the general superintendence of the Engineer Department. He shall regulate the duties of the officers of the Corps of Engineers and of all other officers and agents who may be employed in the Department; and he shall, under the direction of the Secretary of War, have the control of such officers and agents in everything relating to their duties in the Department, and to the disbursement of the funds placed in their hands in the performance of those duties. He shall personally inspect the public works of the Engineer Department at such times as he may think necessary. * * * The order of the Secretary of War relative to the Military Academy will be communicated through him. * *. * A permanent superintendent of the academy, appointed from the Corps of Engineers, will have the immediate government of the institution, and be held responsible for its correct management. * * * No officer of the army, of any rank whatever, except the commandant of the Corps of Engineers, shall exercise command in the Military Academy, unless subordinate to the superintendent. * * *

Ordnance Department.—The senior officer of the Ordnance Department is, under the direction of the Secretary of War, charged with its superintendence and administration. He will be stationed at the seat of Government. * * * There shall be established, under the direction of the Secretary of War, as many arsenals of construction as the public service may require, &c. * * * Arsenals of construction shall be under the immediate command and direction of officers of the Ordnance Department. * * *

Subsistence Department.—The Commissary-General of Subsistence is stationed at the city of Washington, and has, under the direction of the Secretary of War, the general superintendence of the Subsistence Department, &c. * * *

Pay Department.—The Paymaster-General is stationed at the seat of Government, and, under the direction of the Secretary of War, is charged with the administration of the affairs of his Department and the control of the officers connected therewith, &c.

Medical Department.—The Surgeon-General is stationed at the city of Washington, and is, under the direction of the Secretary of War, charged with the superintendence and administration of the Medical Department. * * *

Purchasing Department.—The Commissary-General of Purchases will, under the direction of the Secretary of War, purchase all clothing, dragoon saddles and bridles, tents, tent-poles, camp-kettles, mess-pans, bed-sacks, &c.[1] * * *

Clothing Bureau.—The officer at the head of the Clothing Bureau is charged with the correspondence of the War Department upon all subjects connected with the clothing of the army.[2] * * *

Under the head of "The Staff of the Army," the duties of the subordinate officers of the staff corps, bureaus, and departments are thus stated in these Regulations:

These officers act in the name of the commanders *under whom they are placed,* or perform their functions according to the rules and regulations established for the government of their *respective Departments.*

In the edition of the General Regulations promulgated January 25, 1841, the article in regard to the commander of the army was slightly but not essentially modified, and was in the following words:

ARTICLE X.—THE COMMANDER OF THE ARMY.

48. The Military Establishment is placed under the orders of the major-general commanding-in-chief in all that regards its discipline and military control. Its fiscal arrangements properly belong to the administrative departments of the staff, and to the Treasury Department, under the direction of the Secretary of War.

49. The General will watch over the economy of the service in all that relates to the expenditure of money, supply of arms, ordnance and ordnance stores, clothing, equipments, camp equipage, medical and hospital stores, barracks, quarters, transportation, fortifications, military academy, pay and subsistence; in short, everything which enters into the expenses of the Military Establishment, whether *personal* or *national.* He will also see that the estimates for the military service are based upon proper data, and made for the objects contemplated by law and necessary to the due support and useful employment of the army. In carrying into effect these important duties, he will call to his counsel and assistance the staff and those officers proper, in his opinion, to be employed in verifying and inspecting all the objects which may require attention. The rules and regulations established for the government of the army, and the laws relating to the Military Establishment, are the guides to the commanding general in the performance of his duties.[3]

The functions and duties of the officers of the staff corps, bureaus, and departments were reiterated in this edition of the Regulations, substantially the same as in the preceding one. In the edition promulgated May 1, 1847, Article X was repeated exactly as in the one of 1841, and the functions and duties of the subordinate branches were continued as in the latter edition.

It might appear to those having independent notions of military organization and administration, derived from viewing the Military Establishment (in the wide sense hereinbefore explained) from a stand-

[1] These duties were subsequently merged in those of the Quartermaster and Ordnance Departments.

[2] Subsequently turned over to the Quartermaster Department.

[3] See foot-notes 2, 3, and 4, p 86.

point wherein the power and prestige of the military, *as military* alone and without any reference whatever to the claims of *civil government*, are considered, that the whole Establishment should, upon purely military principles, be placed under the orders of a military officer commanding-in-chief; that, in fine, besides handing over to this chieftain for discipline and control the armed body denominated the army or armies, all other governmental provisions or contributive systems, having for their objects the furnishing to the army or armies the means necessary for subsistence, comfort, mobility, and action, should in their entirety be placed permanently under his command and control. Doubtless, in the mind of the military enthusiast this theory is the correct one. But the military being the creature of the civil power, it is axiomatically true under our form of Government that the former must be subordinate to and dependent upon the latter so long as the last vestige of lawful civil Goverment remains capable of civil administration and protection. In the expiring throes of civil Government the military is, it is true, exalted to a supreme preëminence by consent of both Government and people; but these are extraordinary and exceptional occasions, and the prerogatives which inure to the military under such circumstances are curtailed and reduced upon the return of civil power. How far these prerogatives shall remain, consistent with the genius of civil liberty after civil Government has been enthroned, has wisely been vested by our Constitution in the determination of Congress, who, by it, is made the creator, preserver, and benefactor of all armies. And so we find Congress, the direct representatives and agents of the whole body of the people in their sovereign civil capacity, empowered to "raise and support" armies; to "declare war;" to "make regulations for the government of the land and naval forces;" and to make "provision for the common defense." Congress makes provision for the common defense and for the support of armies through such agencies and instrumentalities as it in its wisdom deems fit, without regard to any abstract "military principles," which are not binding upon it—it rather makes principles as it proceeds, and "bends the neck of military power under the yoke of law."

Overlooking the policy of civil Government and the supremacy of the legislative will, it might at first view appear to the military theorist that the articles relating to "the commander of the army," heretofore quoted, placed the entire Military Establishment, in its wide sense, under the orders of the senior general-officer of the army. It is not known that, practically, these articles were ever given such an interpretation. At no period of General Scott's incumbency was he known to have raised the pretension that upon "fundamental military principles," or by reason of these articles, he should be made a supreme military functionary in the War Department, with jurisdiction coextensive with every branch of the entire Military Establishment, or concurrent with that of the Secretary of War. While the

articles were retained in the Regulations, their generalities might possibly have afforded color to the general officer for extending his military jurisdiction whenever a weak administration, or one overzealous in the interest of the military, should by inadvertence or design yield to the pretensions that might have been founded solely upon them; and it would not have been surprising to find that when such unsettled notions of the organization of the War Department had come for a time to prevail, they would have been subsequently righted by vigorous orders issued in vindication of the lawful prerogatives of the Secretary's office. But the statute laws (still in force at the present day) on which these Regulations were founded were so explicit in regard to the jurisdiction of the Secretary of War over what has herein been characterized as sedentary duties that the senior general officer never was moved by military or other principles to question it. At both periods of succession in the office of major-general (1828 and 1841) questions of precedence arising out of seniority of brevet commissions afforded an all-absorbing topic of discussion between the fortunate major-general and the less fortunate but aspiring brigadiers.[1] To such an extent was this discussion carried after General Scott's accession to the major-generalcy and assignment to the command of the army, that the House Military Committee in 1842 inquired into the expediency of abolishing altogether the office of major-general. On this subject the then Secretary of War wrote as follows,[2] after quoting from the report of his predecessor in 1828, hereinbefore referred to:

These views are adopted, and fully and entirely concurred in by me. Their soundness and accuracy, it is believed, will commend them to the favorable consideration of all. A few of the topics suggested by General Porter (the previous Secretary) are susceptible of some modification, although probably without much addition to their strength. The civil avocations of the Secretary of War, which fourteen years ago he stated to be so numerous "as to put it wholly out of his power to attend to the daily orders and complicated routine of duties which appertain to the command and discipline of an army," so far from diminishing since that period, have been augmented and multiplied to an extent that renders the argument perfectly conclusive.

The functions of a Secretary of War are of a civil and not of a military character, and are administrative rather than executive. His business is more to superintend the general arrangements of the service, regulate its expenditures, and enforce responsibility than to exercise command. It can rarely happen that he possesses an acquaintance with the details of service or experience in the art of war. By associating with him, at the seat of Government, an officer of rank having these qualifications the system is rendered complete, and the various talent requisite to the faithful and successful administration of the concerns of the army may be brought into operation.

To devolve the peculiar duties of a commanding general upon an adjutant-general would be making him, in fact, the commanding general. All that would be gained would be a change of title, and instead of a major-general commanding the army an adjutant-general would do so. The nature of the duties of the office of adjutant-general is wholly different from those of a commander. He is, in fact, the adjutant of the commander; and we might as well abolish the office of colonel of a regiment and place its adjutant in command of the lieutenant-colonel and major as to place the adjutant-general, whose official rank is that of colonel, in command of brigadiers.

[1] Fry's Brevets, pp. 103, *et seq.*; 127, *et seq.*

[2] Ibid., p. 130.

After the expression of these views it is scarcely necessary to add that, in the opinion of this Department, it is impracticable, consistently with the existence of our army, to dispense with the performance of the duties appertaining to a commanding general-in-chief.

Neither this Secretary nor any of his predecessors ever counselled or agreed to the interposition of the senior general officer between himself and the staff corps and bureaus of his Department. Communications from the Secretary of War and them were always direct, on matters within their respective provinces; and orders and directions affecting them collectively, or of which the army at large were to take notice, were issued through the office of the Adjutant-General. On November 21, 1842,[1] the Adjutant-General promulgated the following order of the Secretary:

The movements of officers subject to the orders of the chiefs of the different bureaus are so connected with the general administration of the Department as to render it advisable that the practice of consulting the Secretary of War, which now prevails in most cases, should exist in all. Whenever, therefore, the officer in charge of any bureau deems a change desirable in the station or duties of any officer subject to his orders, he will report the same in writing, with a brief statement of the reasons for such change, to the Secretary of War, by whom the proper directions will be given.

In March, 1843,[2] the Secretary of War extended the provisions of paragraph 140 of the Regulations (in regard to taking and granting leaves of absence in the army) to the "heads of bureaus in the War Department and the officers under their charge," and directed that applications by such officers for leaves, for periods exceeding that specified in paragraph 140, should be addressed to the Secretary of War through the chiefs of bureaus to which the officers might belong.

In April, 1843,[3] the Secretary of War laid down, among others, the following rules, to "govern in all cases, except where a deviation may, under special circumstances, be found necessary, when directions for the purpose will be given by the War Department: 1st. Arsenals, being under the control of the Ordnance Department, will not be interfered with by any other branch of the service. 2d. New works (fortifications) in process of construction under the direction of the Chief of Engineers will, in like manner, be under the control of the Engineer Corps, without interference."

In December, 1847,[4] an order was published, announcing that the subordinate officers of the Pay Department were "subject only to the orders of the Secretary of War and the Paymaster-General, except that they are liable to arrest by the senior officer of the Department or command to which they are arranged for the regular payment of the troops."

From 1821 to 1842 the country had been divided into two geographical divisions, each commanded by a brigadier-general, the major-

[1] G. O., November 21, 1842, A. G. O.
G. O., March 4, 1843, A. G. O.
[3] G. O., April 8, 1843, A. G. O.
[4] G. O., December 31, 1847, A. G. O.

general commanding-in-chief being stationed at Washington.[1] These two divisions were discontinued is 1842,[2] and the United States were redistricted, for the purpose of securing more direct channels of communication with the troops, into nine military departments, under the brigadiers and colonels in the service, the major-general being retained in Washington. This disposition continued until the period of the Mexican war, during which the major-general commanding-in chief, together with other major-generals temporarily appointed for the war, was absent with the army in Mexico. Upon his return, in 1848,[3] an order was issued from the War Department re-establishing the two geographical divisions, the command of the Eastern being given to General Scott, the senior major-general, with headquarters at New York, and that of the Western to Maj. Gen. Zachary Taylor, with head-quarters at or near New Orleans. These two commands were independent of each other, and were made so out of deference to General Taylor, who at the time was before the people as a candidate for the Presidency, and who might, therefore, in the possibility of events, become General Scott's official superior. General Taylor was elected to the Presidency, and inaugurated March 4, 1849. On May 10,[4] following, he caused an order to be issued through the War Department, directing Major-General Scott to "assume the command of the army and the duties in all that regards its discipline and military control, according to the regulations prescribed for the guidance of the general commanding-in-chief." This order, it will be observed, assigned the major-general to the command of the "army," and did not place the entire Military Establishment under his orders.

Throughout all these changes in the command of the army the "subordinate branches" of the War Department remained undisturbed—the "sedentary duties" were under the exclusive control and supervision of the Secretary of War, while the "active military duties" were performed in and with the army under commanders to whom the officers of these branches were assigned. In 1851[5] the Secretary of War in orders called attention to the enormous expenditures in the army recently brought to his notice, and stated, for the information of all concerned, that "the commanders on the frontiers should understand that officers of the staff are assigned to duty as their *assistants*—that it is the duty of all commanding officers to watch over the public expenditures in every branch of the service within their *commands*, and that for all excesses such commanders are held responsible." This was the widest construction ever given by the Secretary of War to that portion of Article X which required the general to watch over the economy of the service in "everything which enters into the expenses of the Military Establishment, whether personal or national"; and, as will be observed,

[1] See Army Registers.
[2] G. O., No 17, A. G. O., April 20, 1842.
[3] G. O. No. 49, A. G. O., August 31, 1848.
[4] G. O., May 10, 1849, A. G. O.
[5] G. O., A. G. O., 1851.

this order referred only to expenditures made by staff officers assigned to duty (with public funds for immediate use) with commanding officers of the army on the frontiers and elsewhere.

In the political campaign of 1852 General Scott was a candidate for the Presidency, and was defeated. On March 31, 1853, after the inauguration of Franklin Pierce, his competitor, and the appointment of Jefferson Davis as Secretary of War, both of whom had been subordinates of Scott in the Mexican war, and the latter of whom had subsequently become a Senator, the headquarters of the army[1] were, at the request of General Scott, permitted to be "re-established in the city of New York as immediately prior to November 1, 1850." In October, 1853,[2] the existing geographical divisions and departments were abolished, and five new departments—viz, departments of the East, West, Texas, New Mexico, and the Pacific—were established.

In a long and angry correspondence which took place between General Scott and Mr. Jefferson Davis, Secretary of War in 1855,[3] the former charged the latter with having "silently abrogated the 48th paragraph" of the Regulations of 1847 (Article X, heretofore set forth), to which the latter replied:

> With regard to paragraph 48 of the Revised Regulations of May 1, 1847, which you make it a matter of accusation that I have silently abrogated, I have to say that it never received the construction which your complaints imply, for the exclusive control of the *Military Establishment* has never been surrendered to the senior general of the army, as the unvarying practice of the War Department exhibits.

General Scott's charge had reference to the practice of the Secretary of issuing orders to and corresponding directly with the department commanders and other officers, without such orders and correspondence going through his (Scott's) hands as the general commanding-in-chief. Said he in a subsequent communication:[4]

> And here, to show what powers the law has withheld from you [the Secretary], I shall give the functions delegated by Congress, a subject which you have touched upon (by design) mincingly and obscurely:
>
> 1. The act creating the War Department (August 7, 1789) gives to the Secretary, besides the custody of records, books, and papers of the old Department, the records of military commissions, the care of warlike stores, and other duties clearly ministerial.
>
> 2. Section 5, act March 3, 1813, specifies and delegates power over quite a number of matters relative to stores and supplies; all clearly administrative.
>
> 3. Articles of War 13, 18, and 19 intrust the same functionary with muster-rolls and returns, and give him authority over the forms of such papers and to require stated returns.
>
> 4. The 65th of the same articles makes him the medium in passing proceedings of certain courts-martial, and the organ of the President's orders thereon.
>
> 5. Another article of war (the 95th) charges the Secretary with receiving accounts of the effects of deceased officers and soldiers.

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[1] G. O. No. 7, A. G. O., March 15, 1853.

[2] G. O. No. 25, A. G. O., October 31, 1853.

[3] Sen. Docs., third session Thirty-fourth Congress, vol. 7, doc No. 34.

[4] Ibid., p. 210.

6. Act May 18, 1826, section 1, respecting clothing, &c., charges certain duties upon the Quartermaster-General, under the direction of the Secretary of War.

7. Several acts authorize the Secretary to purchase sites for arsenals.

8. The Ordnance Department and its *metèriel* are made subject to the Secretary of War by the act of February 8, 1815; and—

9. Under the act of March 2, 1803, section 1, the Secretary of War is authorized to give directions to the State Adjutants-General in order to produce uniformity in returns, and to lay abstracts of same, &c.

Possibly in this enumeration some other delegations of authority to the "principal officer" in an Executive Department, on like matters, may have been overlooked;[1] and in every case enumerated he may, doubtless, as of and for himself, give his orders to all concerned, and delegate such authority, at least in part, to others; but taking the rule of the Constitution (tenth amendment) that "powers not delegated" are reserved or withheld, where shall we find in our code a tittle of legislation giving that civil functionary rank and command in the army, or the right to issue orders of a strictly military character (not in the name of the President) to the United States troops or any one of their commanders?

In this controversy General Scott did not impugn altogether the right of the "civil functionary" to issue military orders, but insisted that when issued to himself and the other "higher army officers," the said civil functionary should "condescend to speak in the name of the President."

The pretensions of General Scott in this regard were never recognized; nor should they have been. Said the Secretary, on July 25, 1855,[2] in reply:

You seem to propose for my observance a rule in which the rank of the military officer is to determine the manner in which the Secretary of War will communicate orders to him. Such a rule could only rest on the supposition that the Secretary of War has relative rank among the officers of the army, which is too absurd for consideration.

And the Attorney-General, in an elaborate opinion of twenty octavo pages (rendered August 31, 1855, in answer to the question of the President himself: "Are instructions issued by the heads of Departments to officers, *civil or military*, within their respective jurisdictions, valid and lawful without containing express reference to the direction of the President, and is or not such authority implied in any order issued by the competent Department?") more than confirmed the Secretary in the position he had taken. Said the Attorney-General,[3] in concluding his opinion:

I conclude, therefore, on the authority of judicial decisions, and of the arguments constitutional and statutory herein adduced, that, as a general rule, the direction of the President is to be presumed in all *instructions* and *orders* issuing from the competent department; and that official instructions issued by the heads of the several Executive Departments, *civil* or *military*, within their respective jurisdictions, are valid and lawful, without containing express reference to the direction of the President.

[1] The reader need hardly be assured that many had been overlooked in this paper.

[2] Sen. Docs., third session, Thirty-fourth Congress, vol. 7, doc. No. 34, p. 172.

[3] Ibid., pp. 182–201; see also 7 Opin., 453.

And the President indorsed this opinion as follows, September 5, 1855:[1]

The conclusions of this opinion are approved, and will be regarded as the settled doctrine as to the relations of the President to the respective heads of Departments.

A revised edition of the Army Regulations was published January 1, 1857, containing, as General Scott afterwards characterized it, "The peculiar and offensive views of the late Secretary."[2] This edition omitted entirely Article X, which General Scott, in a letter to the new Secretary of War,[3] written to influence an abrogation of these Regulations, characterized as "a very remarkable omission, evidently designed to affect my [his] office and authority in the army." But the Secretary of War wrote him, on September 25, 1857,[4] as follows:

The failure to insert in the new Regulations a definition of the duties and authority pertaining to the office of Commander-in-Chief of the army which was contained in the old Regulations, I am satisfied, does not in any degree take from it any power, authority, honor, or command conferred upon that high office by law. Definitions are always difficult, sometimes impossible. The definitions in the old Regulations attempting to define the duties of the principal officers of the army are not, in my judgment, satisfactory; and I think the new Regulations wisely follow the example set by those which you prepared in 1825, in which no definitions were attempted.

The provisions of Article X were entirely omitted from the editions of the Regulations of 1861 and 1863, the latter of which has been in force from 1863 to the present time, and under which the Lieutenant-General in 1864, and the General of the Army in 1866, first began the exercise of their offices.

From the foregoing outline of the functions of the Secretary of War in his relations to the Military Establishment, and to the command of the army since the inauguration of the system by Mr. Calhoun in 1821, it will be seen that he has been, since the war of 1812, uninterruptedly exercising, in pursuance of law and Army Regulations, jurisdiction both civil and military over the entire Military Establishment, and that over certain portions he has exercised jurisdiction to the exclusion of "the army" or "armies" proper, the latter standing in the relation of beneficiaries of the several portions administered by him; that these portions included *personnel*, *matériel*, industrial and business operations, and ministerial duties connected with the development of the military strength and defense of the entire country during peace and war, and the support and maintenance of such armed bodies of men, whether regulars, volunteers, or militia, as the exigencies of the public service in peace and war required; that the chiefs of these subordinate branches assisted the Secretary of War in the exercise of that control over the public moneys devoted to military affairs, and over the public stores procured for warlike purposes, which pertain to him in his ministerial capacity; that the vesting of exclusive jurisdiction over these portions in a great civil officer, instead

[1] Sen. Docs., third session, Thirty-fourth Congress, vol. 7, doc. No. 34, pp. 179–180.
[2] Fry's Brevets, p. 204. [3] Ibid., pp. 203–206. [4] Ibid., p. 207.

of in the officers commanding troops, was a wise distribution of executive power, whereby the armed bodies of men necessary for the purposes of government are rendered physically dependent, in their organized warlike capacity at least, on the responsible head of the civil Executive Department for War, answerable to the President who commands, and to Congress who "supports" such warlike bodies; and that since the year 1821 the senior general officer of the regular army had, by custom only, and not by any statutory authority, or any military authority derived immediately from or mediately through his commission as major-general, acted in Washington and elsewhere as "commanding the army."

Thus matters stood at the outbreak of the late war of the rebellion. Brevet Lieutenant-General Scott acted as "commanding the army" until November, 1861, when he was superseded by Major-General McClellan; subsequently, Major-General Halleck discharged these functions until March 10, 1864, when Lieutenant-General Grant, just promoted to that grade, was placed in "command of all the armies of the United States." Throughout this gigantic struggle the subordinate branches of the War Department performed their functions under the direction of the Secretary of War. The immediate control and supervision of the Secretary of War over the subject of army transportation was specifically vested by Congress in that officer, by act of January 31, 1862. At the conclusion of this war the Secretary of War rendered the following tribute[1] to these subordinate branches:

By the heads of the respective bureaus of the War Department and their staffs, the Government has been served with a zeal and fidelity not surpassed by their brethren in the field. To them the honors and distinctions of an admiring public have not been offered, but in their respective vocations they have toiled with a devotion, ability, and success for which they are entitled to national gratitude.

REVIVAL OF THE GRADE OF GENERAL OF THE ARMY OF THE UNITED STATES.

Section 1 of the act of July 25, 1866, chapter 232, enacted that—

The grade of General of the Army of the United States be, and the same is hereby, revived; and that the President is hereby authorized, whenever he shall deem it expedient, to appoint, by and with the advice and consent of the Senate, a General of the Army of the United States, to be selected from among those officers in the military service of the United States most distinguished for courage, skill, and ability, who, being commissioned as General, may be authorized, under the direction and during the pleasure of the President, to command the armies of the United States.

This grade of General of the Army (or rather Armies) of the United States had been created, as we have seen, in 1799, and was withheld by President Adams from being conferred on no less a personage than the illustrious Washington, because it was judged to touch, if it did not encroach upon, the constitutional functions of the Presidential office.

The act of 1866 did not direct the President to assign the appointee to command, whether or not, after appointment, but simply rendered the

[1] Annual Report of Secretary of War, November 22, 1865.

appointee eligible to the command "under the direction and during the pleasure of the President," in precedence of all other general officers. Evidently, then, the General might be appointed, but with no claim, statutory or otherwise, to command as against the pleasure of the President. The appointment having actually been made during a period of peace, the officer became nominally General of the Army of the United States, provided by the law which revived the grade with a staff appropriate to a general officer in the field, consisting of a brigadier-general as chief of staff and six colonels as *aides*. The grade does not, *per se*, entitle the recipient to the command of anything beyond his own immediate staff officers, except at the pleasure of the President. In the absence of the *assignment* contemplated by the law, no function of office, civil or military (except the function of drawing the pay and emoluments allowed by law, and the control of his staff officers), can by right be exercised by him. No office nor function of any office existing at the time of his appointment, aside from the limited office marked out to him by the act, could have been recovered by him under a writ of *quo warranto*. Brought to this legal aspect, it will be conceded that there were none whatever. That this is the true view to take of the law relating to the office of General of the Army, will be conceded by every lawyer, and certainly no one will claim that an officer can by virtue of his commission alone "put himself on duty" in any grade of the service without orders from competent authority.

It is historically true, however, that the recipient of the grade in 1866 was not formally assigned to duty *in that specific grade* by the President. Being already in "command of the armies of the United States" as lieutenant-general, under the Presidential order of March 10, 1864, it may not have been deemed necessary to issue a formal order, but to consider the new office as a change of title only.

The disruption which occurred between the President and Congress in 1867 on the reconstruction measures, and the contention over the right of the President to remove at pleasure his constitutional advisers, were the occasion of placing the discharge of the purely civil duties of the Secretary of War in the hands of officers of the regular army by the appointment of one of them as Secretary of War. The policy of Congress towards the reconstructed States, in opposition to that of the President, required the administration of the Congressional measures through military instead of civil sources. In March, 1867, an act was passed fixing the headquarters of the army at Washington, and the jurisdiction of the General and the routine of his office were thus marked out:

> And all orders and instructions relating to military operations, issued by the President or Secretary of War, shall be issued through the General of the Army, and, in case of his inability, through the next in rank. The General of the Army shall not be removed, suspended, or relieved from command, or assigned to duty elsewhere than at said headquarters, except at his own request, without the previous approval of the

Senate; and any orders or instructions relating to military operations issued contrary to the requirements of this section shall be null and void; and any officer who shall issue orders or instructions contrary to the provisions of this section shall be deemed guilty of a misdemeanor in office; and any officer of the army who shall transmit, convey, or obey any order or instruction so issued contrary to the provisions of this section, knowing that such orders were so issued, shall be liable to imprisonment for not less than two nor more than twenty years, upon conviction thereof in any court of competent jurisdiction.

This provision was contained in an appropriation act, in approving which the President called attention to and protested against this section as virtually depriving him of certain of "his constitutional functions as Commander-in-Chief of the Army"; and in his annual message of December 7, 1868, he directed especial attention to it, and urged that it be annulled, because it might "in times of great emergency seriously embarrass the Executive in efforts to employ and direct the common strength of the nation for its protection and preservation." Referring to this and other laws deemed by him encroachments upon the prerogatives of the Presidential office, he said:

It is believed that the repeal of all such laws would be accepted by the American people as at least a partial return to the fundamental principles of the Government, and an indication that hereafter the Constitution is to be made the nation's safe and unerring guide. They can be productive of no permanent benefit to the country, and should not be permitted to stand as so many monuments of the deficient wisdom which has characterized our recent legislation.

On the 12th of August ensuing the passage of the act fixing the headquarters of the army at Washington, the President, having invited the incumbent of the office of Secretary of War to resign, but without effect, proceeded to suspend him from office, and appointed the General of the Army to act as Secretary of War *ad interim*.[1] This temporary transfer of the office to a military personage continued until January 13, 1868, when, the Senate having non-concurred in the suspension of the Secretary of War, the latter resumed the duties of the office, under the tenure-of-office act—another law obnoxious to the Presidential prerogatives—and continued to discharge them without any personal or written communication with the President,[2] although the latter was and is the chief Executive and Commander-in-Chief of the army. The surrender of the office to the resuming Secretary by the General of the Army, without giving notice to the President of his intention to do so, occasioned some correspondence[3] between the President and the General, immediately after the event, in which the latter referred to the Secretary of War as "my *superior*, and your (the President's) subordinate." On the 21st of February, the President, notwithstanding the action of the Senate in regard to the suspension, empowered the Adjutant-General to act as Secretary of War *ad interim*,

[1] McPherson's Reconstruction, pp. 282-293.
[2] Ibid., p. 282.
[3] Ibid., pp. 283-293.

and notified the Secretary of War of his outright removal from office. The Adjutant-General was immediately intercepted by legal process, however, under the tenure-of-office act, and the impeachment of the President ensued, the Secretary remaining personally within the walls of the War Department until the impeachment proceedings had been abandoned in the Senate, whereupon he notified the President on that day (May 26, 1868) that he had "relinquished the charge of the War Department."[1]

Pending the proceedings on the articles of impeachment, and in entire consistency with the President's theory of his constitutional rights in regard to removals, he sent in a nomination to the Senate to fill the vacancy which he assumed he had made in the office of Secretary of War.[2] This nomination was of a brigadier-general, still holding his commission in the regular army, who was confirmed after the impeachment proceedings had broken down, and the incumbent holding over had "relinquished his place as Secretary of War."

On the 31st of May, 1868, the General of the Army was nominated for the Presidency, and was elected in the ensuing fall. It was known that, upon the accession of the new President, the Lieutenant-General was to be promoted to be General, and the chief of staff of the retiring General was to be appointed Secretary of War. Before this latter appointment was made, however, the then Secretary of War issued an order under date of March 5, 1869,[3] marking out the following jurisdiction for the incoming General of the Army, viz:

By direction of the President, General William T. Sherman will assume command of the army of the United States.

The chiefs of staff corps, departments, and bureaus will report to and act under the immediate orders of the General commanding the army.

All official business which, by law or regulations, require the action of the President or Secretary of War will be submitted by the General of the Army to the Secretary of War; and, in general, all orders from the President or Secretary of War to any portion of the army, line or staff, will be transmitted through the General of the Army.

In assuming command under this order, the General of the Army announced the following chiefs of War Department bureaus and officers as his *general* staff,[4] viz: The Adjutant-General, an Inspector-General, the Quartermaster-General, the Commissary-General of Subsistence, the Surgeon-General, the Paymaster-General, the Judge-Advocate-General, the Chief of Engineers, the Chief of Ordnance, and the Chief Signal Officer. This general staff consisted of nine major-generals by brevet, and one brigadier-general by brevet, while his *personal* staff, announced at the same time, was to consist of his six *aides-de-camp* allowed by law, all having the full rank of colonel.

The new Secretary of War, however, soon found that this investiture of the War Office ran counter to the laws and traditions of his office,

[1] McPherson's Reconstruction, p. 263.
[2] Ibid., p. 264.
[3] G. O. No. 28, March 5, 1869.
[4] G. O. No. 11, A. G. O., March 8, 1869.

and unsettled a routine as ancient as the Department itself. Upon direct personal protestation to the President,[1] therefore, he succeeded in having the order of March 5 abrogated, except only that part which directed the General to "assume command of the army of the United States." A jurisdiction was thereupon defined for the General of the Army substantially the same as that which had been allowed to the senior general officer of the army since 1821, and was as follows:[2]

All orders and instructions relating to military operations issued by the President or Secretary of War will be issued through the General of the Army.

It was required this year that the annual reports of the chiefs of the various subordinate branches should be submitted to the Secretary of War through the headquarters of the General of the Army. This, however, was rescinded in subsequent years.

The same session of Congress which revived the grade of General of the Army also directed the Secretary of War[3] to have prepared and submitted to Congress a code of Regulations, the existing Regulations of 1863 to remain in force until Congress should act on the new code. The ensuing period of political excitement prevented any action being taken in this direction, and in 1870 the Secretary was again directed to prepare a system of Regulations, "not inconsistent with the laws of the United States," which, when approved by Congress, were to be in force and obeyed until altered or revoked by the same authority. This last enactment (act July 15, 1870[4]) contained the following significant provisions: 1st, it repealed the law fixing the headquarters of the army in Washington, and that provision requiring "all orders and instructions relating to military operations issued by the President or Secretary of War" to be "issued through the General of the Army, and, in case of his inability, through the next in rank"; and, 2d, it enacted that "*the offices of general and lieutenant-general shall continue until a vacancy shall occur in the same, and no longer.*"

Soon after the passage of this last act a board of military officers was assembled, who, after much labor and inquiry into the practical needs of the service, finally prepared a code, which, with some modifications, was submitted to Congress by the Secretary of War too late in the session of 1872–'73 for proper consideration by the House Military Committee, and it was accordingly ordered to be printed only.[5]

This system of regulations, prepared "IN AID OR COMPLEMENT TO THE STATUTES," defined and prescribed the details for carrying on the routine work of the army. Although not entirely free from defects in minor particulars, it nevertheless embodied the fundamental idea that the Secretary of War was the civil minister, for and in the place of the

[1] Speech of Senator Sumner, May 31, 1872, in United States Senate.
[2] G. O. No. 28, A. G. O., March 27, 1869.
[3] 14 Stat. at Large, 338.
[4] 16 Stat. Large, 318.
[5] See Report No. 85, H. R., Forty-second Congress, third session.

President, presiding over the Executive Department for War. After defining the various branches of the military service, including the *special staff* or *administrative services*, it laid down broadly the proposition that "*The Secretary of War is the head of the administrative service of the army, and has control of its branches.*"

The act of July 15, 1870,[1] directing the preparation of these regulations, enacted that *when approved by Congress* they should "be in force and obeyed until altered or revoked by the same authority." If approved, therefore, by Congress, as reported, it would have been illegal for the President to alter or amend even the slighest provisions until authority was granted by Congress for the purpose. This unwise restriction being brought to the attention of Congress,[2] a section was passed March 1, 1875,[3] repealing so much of the law as required the Regulations to be reported to Congress, and authorized the President, under that law, "to make and publish Regulations for the government of the army, in accordance with existing laws."

In March, 1876,[4] the General of the Army, with his headquarters and aides, was recalled to Washington from Saint Louis, whither he had gone in 1874,[5] upon his own request, and with the consent of the President. The jurisdiction which he was to fill in Washington was thus set forth in General Orders No. 28, A. G. O., 1876, viz:

> The headquarters of the army are hereby re-established at Washington City, and all orders and instructions relative to military operations, or affecting the military control and discipline of the army, issued by the President through the Secretary of War, shall be promulgated through the General of the Army, and the Departments of the Adjutant-General and the Inspector-General shall report to him, and be under his control, in all matters relating thereto.

The following are the main divisions of the War Department as at present organized, with a general statement of the duties appertaining to each:

THE ADJUTANT-GENERAL'S DEPARTMENT.

The promulgation to the army of orders and instructions relating to military operations, and the conduct of the correspondence between the General and the Army, are the duties of the Adjutant-General. The reception and preservation of muster-rolls and stated reports in regard to the *personnel* of the army; the forwarding of commissions; the superintendence of the recruiting service, and of the military prison at Leavenworth, Kans.; the care of papers concerning the enlistment and drafting of volunteers; the care and custody of the papers and records of the late Bureau of Refugees, Freedmen, and Abandoned Lands; and the furnishing of consolidated reports of the *personnel* of the entire

[1] 16 Stat. Large, 319.

[2] See Report No. 85 H. R., Forty-second Congress, third session.

[3] 18 Stat. Large, 337.

[4] G. O. No. 28, A. G. O., 1876.

[5] G. O. No. 108, A. G. O., September, 3, 1874.

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army for the information of the Secretary of War and the General of the Army pertain also to the Adjutant-General.

All officers of this Department, subordinate to the Adjutant-General, are assigned to staff duty with the army, or to other appropriate duties pertaining to the office of Adjutant-General.

THE INSPECTOR-GENERAL'S DEPARTMENT.

The inspection and report upon the *matèriel* and *personnel* of the army, when ordered by proper authority, and the inspection of army disbursing accounts under the law, are the duties of this Department.

THE QUARTERMASTER'S DEPARTMENT.

The providing, under the direction of the Secretary of War, of quarters and transportation for the army, and of clothing, camp and garrison equipage, horses and mules, forage, wagons, stoves, stationery, fuel, lights, straw, barracks, hospitals, and medicines, the payment of funeral expenses of officers and men, of pay and expenses of guides, spies, and interpreters, and veterinary surgeons, and the charge of the national cemeteries, are the duties which appertain to this Department.

All officers of this Department subordinate to the Quartermaster-General are assigned to staff or other duty with the army, or to appropriate duties in connection with the Quartermaster's Department under the Secretary of War.

THE SUBSISTENCE DEPARTMENT.

The providing, under the direction of the Secretary of War, of the necessary articles and materials for the subsistence of the army, compose the duties of this Department.

All the officers of the Department subordinate to the Commissary-General of Subsistence are assigned to staff or other duty with the army, or to appropriate duties in connection with the Subsistence Department under the Secretary of War.

THE PAY DEPARTMENT.

The duty of this Department is, under the direction of the Secretary of War, to pay the enlisted men and officers of the army.

The officers of the Department subordinate to the Paymaster-General are assigned, under the Secretary of War, to appropriate duties in connection with the payment of the army.

THE MEDICAL DEPARTMENT.

The Surgeon-General, under the immediate direction of the Secretary of War, is charged with the administrative duties of the Medical Department; the designation of the stations of medical officers, and the issuing of all orders and instructions relating to their professional du-

ties. He directs as to the selection, purchase, and distribution of the medical supplies of the army. The Army Medical Museum and the official publications of the Surgeon-General's Office are also under his direct control.

THE ENGINEER CORPS.

The Corps of Engineers, embracing its commissioned officers and battalion, is charged, under the direction of the Secretary of War, with all duties relating to fortifications, whether permanent or temporary; with torpedoes for coast defense; with all works for the attack and defense of places; with all military bridges, and with such surveys as may be required for these objects, or the movement of armies in the field.

It is also charged with the harbor and river improvements; with military and geographical explorations and surveys; with the survey of the lakes, and with any other work specially assigned to the corps by acts of Congress or orders of the President of the United States.

The officers of the corps subordinate to the Chief of Engineers are assigned to staff duty with the army, or to appropriate professional duties throughout the country under the President or Secretary of War.

THE ORDNANCE DEPARTMENT.

The duties of the Ordnance Department, under the direction of the Secretary of War, consist in providing, preserving, distributing, and accounting for every description of artillery, small-arms, and all the munitions of war which may be required for the fortresses of the country, the armies in the field, and for the whole body of the militia of the Union. In these duties are comprised that of determining, subject to the approval of the Secretary of War, the general principles of construction, and of prescribing in detail the models and forms of all military weapons employed in war. They comprise also the duty of prescribing the regulations for the proof and inspection of all these weapons, for maintaining uniformity and economy in their fabrication, for insuring their good quality, and for their preservation and distribution. For carrying into effect the general purposes here stated, large annual appropriations are made, under which extensive operations are conducted at the national armory, arsenals, and ordnance depôts.

The officers of the Department subordinate to the Chief of Ordnance are assigned to staff or other duty with the army, or to the command of arsenals, the armory, or other necessary duties connected with the Ordnance Department, under the Secretary of War.

THE BUREAU OF MILITARY JUSTICE.

The Judge-Advocate-General and his assistant, under the supervision of the Secretary of War, receive, review, and have recorded the proceedings of the courts-martial, courts of inquiry, and military commis-

sions of the armies of the United States, and furnish reports and opinions on such questions of law and other matters as may be referred to the Bureau for the purpose by the Secretary of War.

The officers of the Bureau subordinate to the Judge Advocate-General are assigned to staff or other duty with the army, or to other appropriate duties connected with the Bureau, under the Secretary of War.

THE SIGNAL OFFICE.

The Chief Signal-Officer superintends the instruction of officers and men in signal duties, supervises the preparation of maps and charts, and has the reports from the numerous stations received at Washington consolidated and published, and administers the affairs of the Signal Service under the direction of the Secretary of War.

Officers are detailed from the army proper for tours of instruction in army signaling and telegraphy, and, at the conclusion of these tours, they rejoin their regiments and new details are made.

SECRETARIES OF THE BOARD OF WAR AND ORDNANCE.

1776 to 1781.

[Compiled from the Journals of Congress.]

RICHARD PETERS, elected Secretary to the Board of War and Ordnance, June 13, 1776; appointed a member of the Board of War, November 27, 1777.

JOSEPH NOURSE, elected Deputy Secretary to the Board of War, June 17, 1777; elected Secretary of Ordnance and Paymaster to the Board of War and Ordnance, February 12, 1778; resigned September 16, 1778.

General JAMES WILKINSON, selected to be Secretary of the Board of War, January 6, 1778; resigned March 31, 1778.

Maj. PETER SCULL, elected Secretary to the Board of War and Ordnance, November 4, 1778; resigned September 1, 1779.

Capt. BENJAMIN STODDART, elected Secretary to the Board of War and Ordnance, September 1, 1779; resigned February 14, 1781.

JOSEPH CARLETON, elected Secretary to the Board of Ordnance and Paymaster to the Board of War and Ordnance, October 27, 1779, to date back to resignation of Mr. Nourse, September 16, 1778; elected Secretary to the Board of War, February 17, 1781.

SECRETARIES AT WAR.

1781 to 1789.

General BENJAMIN LINCOLN, elected Secretary at War, October 30, 1781; resigned October 29, 1783.

RICHARD PETERS, requested to continue to exercise the duties of the War Department until the Secretary at War should enter upon the duties of his office, November 19, 1781.

JOSEPH CARLETON, continued as "Secretary in the War Office," November 4, 1783, to March 24, 1785.

General HENRY KNOX, elected Secretary at War, March 8, 1785, and continued until adoption of the Constitution, in 1789.

SECRETARIES OF WAR.

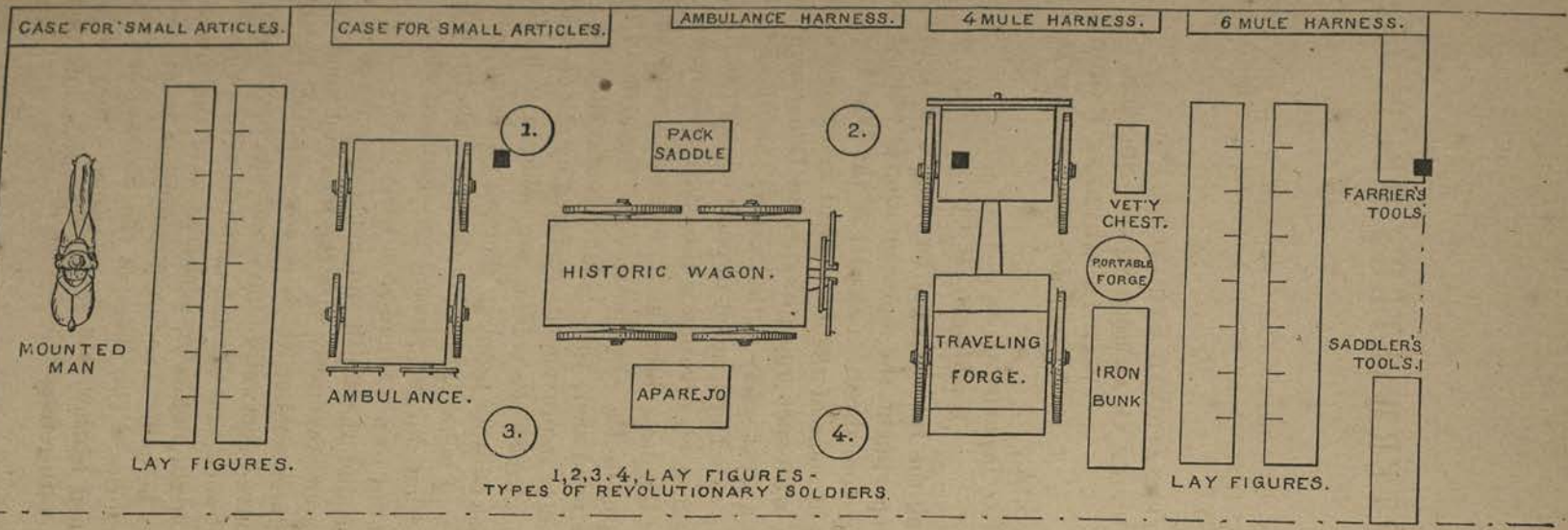
From 1789 to 1876.

Henry Knox, Massachusetts, September 12, 1789.
Timothy Pickering, Pennsylvania, January 2, 1795.
James McHenry, Maryland, January 27, 1796.
Samuel Dexter, Massachusetts, May 13, 1800.
Roger Griswold, Connecticut, February 3, 1801.
Henry Dearborn, Massachusetts, March 5, 1801.
William Eustis, Massachusetts, March 7, 1809.
John Armstrong, New York, January 13, 1813.
James Monroe, Virginia, September 27, 1814.
A. J. Dallas (*acting*), March 14 to August 8, 1815.
William H. Crawford, Georgia, August 1, 1815.
George Graham, Virginia, April 7, 1817.
John C. Calhoun, South Carolina, October 8, 1817.
James Barbour, Virginia, March 7, 1825.
Peter B. Porter, New York, May 26, 1828.
John H. Eaton, Tennessee, March 9, 1829.
Lewis Cass, Michigan, August 1, 1831.
Benjamin F. Butler, New York (*acting*), March 3, 1837.
Joel R. Poinsett, South Carolina, March 7, 1837.
John Bell, Tennessee, March 5, 1841.
John McLean, Ohio, September 13, 1841.
John C. Spencer, New York, October 12, 1841.
James M. Porter, Pennsylvania, March 8, 1843.
William Wilkins, Pennsylvania, February 15, 1844.
William L. Marcy, New York, March 6, 1845.
George W. Crawford, Georgia, March 8, 1849.
Winfield Scott, *ad interim*, July 23, 1850.
Charles M. Conrad, Louisiana, August 15, 1850.

Jefferson Davis, Mississippi, March 7, 1853.
John B. Floyd, Virginia, March 6, 1857.
Joseph Holt, Kentucky, January 18, 1861.
Simon Cameron, Pennsylvania, March 5, 1861.
Edwin M. Stanton, Pennsylvania, January 15, 1862.
U. S. Grant, *ad interim*, August 12, 1867, to January 14, 1868.
E. M. Stanton, reinstated January 14, 1868.
J. M. Schofield, May 28, 1868.
John A. Rawlins, Illinois, March 11, 1869.
William T. Sherman, September 9, 1869.
William W. Belknap, Iowa, October 25, 1869.
George M. Robeson, New Jersey (*acting*), March 2, 1876.
Alphonso Taft, Ohio, March 8, 1876.
J. D. Cameron, Pennsylvania, May 22, 1876.

THE QUARTERMASTER'S DEPARTMENT.

CAPTAIN JOHN F. RODGERS,
QUARTERMASTER'S DEPARTMENT,
IN CHARGE OF QUARTERMASTER'S SECTION, WAR DEPARTMENT PARTICIPATION.



International Exhibition, 1876.

BOARD ON BEHALF U. S. EXECUTIVE DEPARTMENTS.

QUARTERMASTER SECTION,
War Department Exhibit.

THE QUARTERMASTER'S SECTION.

REPORT OF CAPT. JOHN F. RODGERS, IN CHARGE OF QUARTERMASTER'S SECTION, ON THE EXHIBITION IN ITS RELATIONS TO THE QUARTERMASTER'S DEPARTMENT.

INTERNATIONAL EXHIBITION 1876,
OFFICE QUARTERMASTER'S SECTION,
WAR DEPARTMENT EXHIBIT,
Philadelphia, November 11, 1876.

Col. S. C. LYFORD, U. S. A.,
Representative War Department, &c.,
Washington, D. C.:

COLONEL: In viewing the International Exhibition in its relation to the Quartermaster's Department, the representation of which I had the honor to conduct under your direction as part of the War Department exhibit, the usefulness of some of the mechanical inventions displayed comes into comparison with such apparatus as the Department is now in possession of. It is almost solely in this respect that the Exhibition has had any relation to this Department in point of contributing to its advancement. The field of observation is thus narrowed down by the comparative absence of displays of foreign uniforms and camp equipage.

The principal features of the Quartermaster's Department display was the uniforms for enlisted men; these being of recent adoption (1872), and receiving the constant improvements dictated by the necessities of the service and the comfort of the soldier, are believed to be much in advance of the uniforms of other powers. The only specimens of army clothing exhibited were, I believe, those in the Prussian, Spanish, and Swedish collections. They did not present any features which would effect improvement in our own if adopted or assimilated. The fabrics are apparently coarser, and the finish and general appearance of the garments does not compare favorably with the trim and handsome uniform of the United States soldier which is now supplied by this Department. It would have been well to have had an opportunity of observing the English, French, and German uniforms with a view to seeking something which might suggest a modification of the present cavalry and light artillery helmet. The foreign uniforms mentioned were composed of woolen fabrics. The shoes of the Russian and Spanish troops are of oak-tanned leather. In these respects they conform to the American opinion with reference to healthfulness and durability.

The United States exhibit of camp and garrison equipage, embracing tents, tools, cooking utensils, bedding, &c., forms a simple yet comprehensive collection of useful material for the soldier's comfort not excelled, I believe, by that of any foreign power. Other Governments were not exhibitors of their war material in this line, and hence our display was without comparison and the benefit of any modification or adoption that might be suggested had the French, German, and English camp equipage system been displayed. But two items of camp equipage (foreign) came under my observation, namely, tents in the English and Swedish collections. They did not merit any special praise in point of convenience, economy, material, or construction when regarded in comparison with the United States regulation tents. The character of our service in the field, however, makes the question of tentage a more important one than it is in European warfare. Such service as ours on the plains is entirely unknown to European armies, and the lack of necessity for field shelter occasions the apparent indifference on the part of their government to this item of camp equipage. In the German campaign of 1870 tents were not used, and do not, I understand, form an article of supply in the army of that Empire.

The opinions of foreign army officers visiting the Government exhibit were, as far as I am aware, quite favorable. From most of them the completeness of the United States soldier's outfit, and the excellent quality and construction of the uniform elicited expressions of admiration and compliment.

Chiefly amongst the advanced mechanical inventions and improvements that bear direct relation to the manufacture of army clothing are those designed to supersede the system of hand-cutting, and afford the Government unlimited recourse in this direction when emergency requires it. The Quartermaster's Department has for six or seven years past directed its inquiries into this subject, thoroughly investigating the merits of all improvements and experimenting with the various contrivances which gave any promise of progress towards the desired end. It now uses the "Warth traveling cutter," the most complete machine of its character that has so far been presented. This machine formed part of the exhibition of the section under my charge. It was also displayed in Machinery Hall of the main exhibition by the inventor, and has received, I believe, the highest award of merit. Those cutting machines that came under my notice in the general exhibition were the "Fenno," the "English band-knife," and the "Warth" before mentioned.

The "Fenno" machine consists of a swinging arm extending horizontally from an upright shaft or standard in the corner of the cutting-table, and having a universal elbow-joint. The power is transmitted to the knife by bands over three pulleys, one surmounting the standard, a double pulley or "idler" over the elbow-joint, and a smaller one on the perpendicular shaft at the end or cutting head. The blade is a circular knife about 2 or 2½ inches in diameter, revolving at a high speed, and

cutting very cleanly. The objection to this machine, however, is its inability to cut at sharp angles in the interior of the patterns, and that the ends of cuts made by it, when not through and beyond the outline of the material, are not perpendicular; the passage of the blade being, of necessity, in the form of the lower quarter of a circle, thus: , the end of the cut must correspond. The difficulty of cutting at an angle with such a blade is readily understood.

The English band-knife is an adaptation of the band saw; a fine "Perine" blade passing over two wheels or pulleys, one above and one below the cutting-table. The application of this principle to the cutting of soft flexible textile fabrics has been but partially successful. This Department has had the subject of its improvement under consideration for some time. In 1874 General M. C. Meigs, Quartermaster-General of the Army, conceived the idea of applying the band-blade principle to cutting clothing, although not aware that it had been tried previously in England. Under his instructions and with the assistance of the designers and manufacturers of band-saws in this city, two machines were constructed possessing all the improvements bearing upon the former field of its usefulness, and such conveniences, improvements, and adaptations in the cutting board or table as the character of the work demanded. These machines have been in operation at the Philadelphia and Jeffersonville depots for nearly two years, and for certain kinds of work, such as the cutting of linings for garments, pockets, &c., they have proved exceedingly useful and economical. Such machines, while being eminently successful in the operation of the saw, are somewhat difficult of application to the cutting of soft textile fabrics which have to be moved to the blade in the looseness of their own weight. It is in this particular that the traveling machines are preferable and must continue in popular favor until some improved adaptation of the band-blade principle be presented.

The English band-knife is similar to those in use by this Department although apparently wanting in some of the conveniences of our cutting-tables.

Neither of the two cutting-machines referred to (the Fenno or the English band-knife) possesses the merits of the Warth traveling cutter. Its fitness for the purpose for which designed, the simplicity of its construction, and the ease and accuracy with which it can be operated recommend it beyond all others which have thus far been offered.

As inventors usually seek the patronage of the General Government for such of their inventions and improvements as might be of service in its civil and military departments, the opportunities to learn of and observe new mechanical devices are never wanting to its officers.

The question of advancement and economy in the manufacture of army uniforms is always under consideration, and all machinery promising progress towards the desired end is carefully investigated. In this way many inventions in cutting, folding, measuring, sponging, and

other machinery not displayed at the International Exhibition have come under my observation.

A very useful contrivance for determining the wearing qualities of fabrics, that is, their capacity to resist friction, was found in the Russian collection. I allude to the Nap-Meter, the invention of Prof. Modest Kiltary, president, privy counselor of state, &c. The machine is of brass and consists of a double frame, A-shaped, about 13 inches high, in which is a cylindrical flanged wheel 6 inches in diameter. On one end of the shaft of the wheel is the crank and handle, on the opposite end the smaller cog-wheels which move hands on three dials indicating the revolutions made. The face of the wheel between the flanges is covered with Russia leather placed with the flesh side up. Over this wheel a strip of the cloth to be tested is placed, the ends passing into it through a slot, at the inside of which are arrangements to fasten and hold them tight. These fastening arrangements consist of three small curved points on one side of the slot and three similar ones on a drum at the other side; the drum winds up its end through the agency of a ratchet wheel worked by a small key. From the upper part of the frame at opposite sides extend two arms on the ends of which are file-faced friction shoes of steel resting upon and being exactly the width of the wheel's face. These arms are movable and can be raised from the wheel and suspended by little brass hooks while the cloth is being put on or the wheel turned to set the dials. Projecting from the back of the friction shoe is a pin upon which can be placed the leaden weights (round, with small hole in center) so as to give any desired pressure, according to the character of the cloth under test. From the base of the machine rises a small bristle brush which is held against the face of the cylindrical wheel by a small spiral spring with sufficient force to keep brushed away the nap which is worn off at each revolution, thus keeping the surface always clean and free from any material which might interfere with the operation of the wearing apparatus.

The machine is a valuable addition to the mechanical contrivances now used to determine the relative merits of fabrics entering into the manufacture of army clothing. It affords a test not heretofore obtained through any of the appliances in possession of this Department, as it really gives a result positive as to wear, which up to this time could only be arrived at through the somewhat varying and uncertain medium of soldiers' legs and backs.

To illustrate the results achieved by this apparatus (writes Professor Kittary), I will state that a specimen of cloth furnished to the depot at Moscow in 1870 stood seven hundred revolutions (making twenty per minute); specimens claimed to be of the same quality furnished to the same depot in 1875, by several manufacturers, stood only two hundred revolutions. It is evident that the wear of the former is equal to three and one-half times that of the latter.

The cloth-testing (or tearing) machine designed by General M. C. Meigs, Quartermaster-General, exhibited in this section, attracted much

attention from foreign military officers. Drafts of it were applied for by several Governments for the purpose of having similar ones constructed for their service. This machine has been in successful operation in this Department for the past eleven years, and is a valuable and unerring test of the capacity of textile fabrics to bear direct strain.

The adulterations of woolen fabrics at the present day are performed so skillfully that it is only by the most vigilant watchfulness that the interests of the Government can be protected. Deceit in such matters seem to grow apace with improvement, and the counterfeit assimilates the genuine so closely as to defy the ordinary judgment and deceive even the most practiced eye. Inferior wool, wool obtained from tanneries that work sheep-skin, known as "skin" or "felt wool," "reworked wool," shoddy flocks, calf's hair, goat's hair, and other animal fibers, enter into the manufacture of many fabrics represented as being made of pure long-staple fleece wool. The great competition of manufacturers reduces the price of army fabrics so low that it is impossible to make them of the material specified in contracts without actual loss. To make ends meet under this condition of affairs, they resort to the practice of adulteration, which, if successful in deceiving the inspectors, occasions an actual loss to the Government greater than the amount involved in paying a higher price for an honest article. The nap-meter is a valuable contribution to the appliances used for detecting the adulterations. The microscope and the machine for testing the tensile strength of cloth have their uses in this connection; aided by the nap-meter it is difficult to imagine the possibility of inferior and adulterated fabrics escaping detection.

The Warth folding-machine, displayed in the United States Department, Machinery Hall, an ingenious and useful contrivance for the examination and folding of cloths, was examined with a view to its utility in connection with the clothing manufactories of this department. The service it performs is not indispensible to our operations.

In the manufacture of army shoes for several years past the system of metallic fastenings for the soles has been in practice. It was adopted as the most serviceable and economical after reasonable tests of its merits had been made. The particular fastening adopted as the standard was the brass screw made and applied by the "standard screw machine," the invention of M. Lemercier, of Paris, France, with such improvements as had been added to it. The invention was brought out about fifteen years ago and introduced to the French Government. It is the machine now used for the manufacture of shoes for that army. This machine cuts a screw upon a rod of wire and turns it into the sole where it is cut off the requisite length and makes a fastening which it is almost impossible to force apart. It was exhibited in the section of the War Department under my charge in the display of manufacturing apparatuses. Since the introduction of this mode of shoe fastening into the United States similar inventions have been made, amongst which is

the Hotchkiss screw machine, which is very much the same as the Lemercier in its operation but not so well adapted to army use, for the reasons that it is wanting in power to drive the screw through heavy sole leather. In its experiments on army shoes it was necessary to soak the leather to a very soft condition to enable the screw to penetrate it and keep its direction. This, of course, would be injurious for the reason that dampness would remain so long in the leather that the shoes would mold in store. The machine is susceptible of improvement in this regard and may probably be brought up to the condition necessary for heavy work. The exhibitor was encouraged in this idea, it being to the advantage of the Department to have wholesome competition in the commodities which come within the province of its purchases.

The display of leather was very extensive and complete, comprehending English, Russian, Austrian, Swedish, Norwegian, French, Italian, German, Australian, and North and South American tanning of oak, hemlock, and union.

I attended the Leather Congress under special instructions of the Quartermaster-General, for the purpose of inquiring into the various modes of tanning and their relative values, and am at present engaged upon a special report upon this subject, to be made to that officer after the investigations, inquiries, and experiments contemplated shall have been accomplished. In its patronage the Government has heretofore favored oak-tanned leather, requiring its use in boots and shoes manufactured under contract. It is now claimed by the hemlock interest, which represents about 80 per cent. of the tanning of the United States, that their leather is not inferior to oak-tan, and they ask that it be not discriminated against. The determination of the question remains to be seen, and should the test of hemlock leather establish its equality to oak and justify the removal of the existing specification excluding it, the Army obtains the benefit of an increased market to procure its material from. Should it prove otherwise, corroborating the correctness of existing preference for oak, the Army is likewise served by the knowledge of the superiority of a material which forms a very important part of its uniform.

The deliberations of the Leather Congress, composing as it did representatives from the world's tanneries, were important and extensive. The tests prosecuted under its directions were exceedingly accurate and exhaustive, and the results growing out of its action cannot fail to effect an advance in the important branch of industry it represented.

Amongst the novelties in machinery exhibited which came under my observation was the "Stow flexible shaft," an invention which transmits rotary motion through curves of increased or diminished radius at pleasure. It consists of metallic spiral coils, one within the other, inclosed in a leather cover or sleeve, in which it revolves; at one end is a pulley to receive the band, and at the other an arrangement to work drills, bits, &c. This machine was examined with a view to its adaptability to the operation of cloth-cutting machines, but seems not to be ap-

plicable to that purpose. Its plane of usefulness lies more in the direction of boring, carving, smoothing, and polishing woods and metals.

The display of articles bearing upon the subject of means of army transportation did not suggest anything towards the improvement of the harness and wagons now in the service. The needs of the Army in this respect are constantly forced upon the notice of officers charged with the movement of troops and supplies by wagon train, affording play for the natural inventive genius of our countrymen, who are ever ready to detect disadvantages and remedy them. The harness exhibited in the Quartermaster's section was considered very well fitted for the purpose for which designed, excellently constructed, of good materials, and was favorably regarded by foreign visitors familiar with such matters.

In the Australian collection the pack-saddle of that country was exhibited. It differs somewhat from those used in our army, but does not present any novel or special features worthy of adoption. The "aparejo" used for mountain transportation in our army seems to be as well adapted to the purpose as any contrivance of its character which has come under my observation. A very handsomely finished specimen of this kind of pack-saddle, made at Tucson, Ariz., under the direction of the Department, was exhibited in the Quartermaster's section of the War Department.

The horse and mule shoes exhibited were mostly of the patterns used in the army (excepting such as were intended for racing and trotting animals). The Quartermaster's section displayed the "Goodenough," the "Burden," the "Shoenberger" shoes, and the various brands of nails adopted. These, with the exhibit of the army system of shoeing and the collection of equine specimens forming part of the collection of the section, gave evidence of the advanced position the Quartermaster's Department occupied in this branch of its duties.

The only foreign ambulance that came under my notice was one in the Russian collection. This was purchased by the Medical Department and has been forwarded to the Army Medical Museum at the request of Surgeon Woodward. My examination of it being somewhat cursory, in view of the fact that it was to remain and be always available for critical scrutiny and the adoption of any merit it may possess or the incorporation of any of its special features in our own, if desired, I will make but a brief reference to it. The arrangement of its litters seems to be well adapted to the ease and comfort of the wounded and sick, but the body, running gear, and wheels seem rather heavy and cumbersome for a conveyance of that character.

A suggestion as to the manner of illuminating posts and depots is obtained in observing "Watkins's patent portable gas attachment." It is a lamp designed for outside lights, and consists of the ordinary gas-lamp frame and burner, the illuminating medium being naphtha contained in a small reservoir attached to the upper portion of the frame. This

reservoir is intended to hold a sufficient quantity of the fluid to burn from dark until day-light, and give a fair, bright light, at an expense of half a cent an hour. As coal gas is not obtainable at most of the posts such a system of illumination might be introduced with economy and convenience.

Steam power having been adopted by the Quartermaster's Department wherever its use promised economy, the question of the selection of steam engines and boilers has become one of much importance. The International Exhibition opened a field of observation in this line greater perhaps than any industrial exhibition that had preceded it. Hundreds of engines, of various powers, forms, and adaptability were here exhibited in motion together. A close examination of all of them would have taken many weeks. In observing this vast display I was impressed with the merits of the Baxter engine, which seems admirably suited to operations requiring small power and economy of space and fuel. In the manufacturing business of this department it is eminently fitted to the purpose of driving cutting-machines, brass-screwing machines, sewing machines, baling presses, elevators, &c.

Precautions against fire and the possession of effective means for its extinguishment are matters of importance to all departments of the Government having the care of buildings, shipping, or other property subject to destruction by conflagration. In the Quartermaster's Department the best available apparatuses (embracing the latest chemical and mechanical appliances invented) have been always considered indispensable. An addition to our protection in this respect is suggested by an article exhibited in the English department, Machinery Hall, by Haynes & Son, of London. It is called the "hydronette," and is designed to throw a small stream of water from a bucket or vessel which may be convenient. It is portable and not expensive, being a rubber tube with a nozzle and suction and forcing apparatus, simple in its construction and operation.

The Bucher patent extinguisher, manufactured in Saxony, is something of different character from any means now in use for the suppression of fire. It is a chemical compound which upon combustion disengages a gas that extinguishes fire. The special claims of this invention are its immediate availability and its certain action in cases where water is incapable of arresting the progress of flames, as in the burning of spirits, tar, turpentine, oil, tallow, sugar, pitch, photogene, petroleum, benzine, &c. This invention was exhibited in the Saxon collection, and reported to be a very successful means of subduing fires in their incipiency, and performing its functions without the attending damage resulting from the ordinary mode of extinguishment.

This Department is a large purchaser of fuel, that commodity being the principal article under the heading of "regular supplies" in its property division. The expense of fuel at most of the posts in the Territories and far western States is a very large one, owing to the diffi-

culty in procuring it. While there was nothing presented to my observation, amongst the great collection, that suggested in any manner a road out of our difficulties in this particular, they can be in a measure offset by anything increasing economical production of coal or wood. In coal mining about 40 per cent. of the yield becomes in the handling, screening, breaking, &c., what is known as "waste" or "slack," and this article, although the purest of the coal, has hitherto been regarded as useless. For thirty years attempts have been made to utilize such waste by mixing with it resinous cements, such as pitch, tar, asphaltum, &c. Success has attended these efforts in England, I believe, but owing to the greater expense of labor in the United States the process has not been found profitable here. A new process for its conversion into solid fuel, together with the machinery for this purpose, has been invented by E. F. Loiseau, of Philadelphia, who exhibited samples of the fuel made by his process at the International Exhibition. Five per cent. of the fuel produced is clay, this substance being mixed with the slack in process of manufacture to the amount named. What other adhesive ingredients enter into its composition I am not in a position to say, but the production is said to be a very acceptable article of fuel, comparing favorably with ordinary stove coal, and lasting (according to the inventor's claims) 25 per cent. longer. Added to the benefits it is said to possess is the very important one of its reduced cost.

It would be of great advantage to this department if in the next International Exhibition it could have an opportunity to directly compare the results of its system with the results obtained by the same departments of the larger European powers, which probably, being nearer home, will be exhibited more fully than they were at the exhibition just closed. Such a comparison, I believe, would reflect credit upon our own Department, while it might lead to valuable improvements.

From the nature of its duties the Quartermaster's Department of the Army is brought more intimately into contact with the general commercial world than either of the other staff corps. Its interest in the International Exhibition was therefore quite comprehensive, as the articles coming within the range of its supplies embrace everything required by the Army except arms, ammunition, and food. The collection was a school of instruction in a certain sense, practically teaching by pleasing and impressive illustration a lesson otherwise to be learned only through the slow course of experience.

The bringing together on so vast a scale the industries and arts of the civilized world, the opening of so admirable an opportunity for the interchange of ideas in a practical manner upon the progress of nations and of men, the magnificent unfolding of the advanced position of our own and other countries in the arts of peace and war could not fail to impress its benefits upon all branches of the nation's organization, and to prove an incentive to greater endeavors hereafter on the part of those

whose privileged office it is to assist in shaping a course of progress for the country they serve.

Expressing a deep sense of obligation for the uniform courtesy and consideration you have extended to me throughout our intercourse, and trusting that my co-operation may have merited your approval, I have the honor to remain, very respectfully, your obedient servant,

JOHN F. RODGERS,
Captain, in charge of Quartermaster's Section.

Chronological list of chiefs of the Quartermaster's Department.

[The Quartermaster's Department of the Army was organized in June, 1775, pursuant to resolution of the Continental Congress adopted June 16, 1775. It has remained, with some modifications, as a staff organization until the present time. The following is a chronological list of the chiefs of the Department since its inception.]

Name.	Rank.	Title.	Date of appointment.	Where appointed from.
Thomas Mifflin	Colonel	Quartermaster-General	Aug. 1775	Pennsylvania.
Stephen Maylan	do	do	June 5, 1776	
Thomas Mifflin	Brigadier-general	do	Oct. 1, 1776	Pennsylvania.
Nathanael Greene	Major-general	do	Mar. 2, 1778	Rhode Island.
Timothy Pickering	Colonel	do	Aug. 5, 1780	Massachusetts.
Samuel Hodgden	Lieutenant-colonel	Quartermaster	Mar. 4, 1791	Pennsylvania.
James O'Hara	do	do	Apr. 19, 1792	Do.
John Wilkins, jr.	do	Quartermaster-General	June 1, 1796	Do.
John Wilkins, jr.	Major-general	do	June 1, 1799	Do.
Morgan Lewis	Brigadier-general	do	Apr. 4, 1812	New York.
Robert Swartwout	do	Chief Quartermaster's Department.	Mar. 21, 1813	Do.
James R. Mullany	Colonel	Division Quartermaster-General.	Apr. 29, 1816	Do.
George Gibson	do	Division Quartermaster-General.	Apr. 29, 1816	Pennsylvania.
William Cumming	Brigadier-general	Quartermaster-General	Apr. 18, 1818	Georgia.
Thomas S. Jesup	do	do	May 18, 1818	Ohio.
Joseph E. Johnston	do	do	June 28, 1860	Virginia.
Montgomery C. Meigs	do	do	May 15, 1861	Pennsylvania.

Catalogue of the articles of the Quartermaster's Department on exhibition.

Class.	Number.	Articles.
I.—Army clothing	1	File of uniformed figures, present regulation, as follows: (*a*) Hospital steward. Full dress. (*b*) Ordnance sergeant. Full dress. (*c*) Commissary sergeant. Full dress. (*d*) Sergeant major of cavalry. Full dress. (*e*) Chief trumpeter of cavalry. Full dress. (*f*) Chief musician of infantry. Full dress. (*g*) Chief musician of artillery. Full dress. (*h*) First sergeant of engineers. Full dress. (*i*) Private of signal corps. Full dress. (*j*) Private of infantry. Full dress. (*k*) Private of artillery (foot). Full dress. (*l*) Private of light artillery. Full dress. (*m*) Infantry. Fatigue dress. (*n*) Foot man with great coat. (*o*) Mounted man with great coat. File of uniformed figures; not now in use: (*a*) Sergeant major of infantry. 1830–1851. (*b*) Sergeant major of dragoons. 1830–1844. (*c*) Sergeant major of artillery. 1830–1851 (*d*) First sergeant of light artillery. 1855–1872.

Catalogue of the articles of the Quartermaster's Department on exhibition—Continued.

Class.	Number.	Articles.
I.—Army clothing—Continued.	2	File of uniformed figures: not now in use—Continued. (*e*) Sergeant of flying artillery. 1812–1820. (*f*) Musician of cavalry. 1855–1872. (*g*) Private of infantry. *1800.* (*h*) Private of infantry. 1812–1834. (*i*) Private of infantry. 1834–1851. (*j*) Private of artillery. 1820–1830. (*k*) Private of rifles. 1851–1853. (*l*) Private of voltigeurs. 1846–1851. (*m*) Sergeant of Ringgold Light Artillery. 1846–1851. (*n*) Great-coat, infantry. 1812–1834.
	3	Uniformed figures of the Revolutionary army, as follows: (*a*) Washington Life Guard. (*b*) Continental infantry. (*c*) Continental artillery. (*d*) Morgan Rifles.
	4	Campaign hat. Present uniform.
	5	Sealskin cap. Present uniform.
	6	Sealskin gloves. Present uniform.
	7	Cotton (Berlin) gloves Present uniform.
	8	Woolen mittens. Present uniform.
	9	Woolen stockings. Present uniform.
	10	Worsted stockings. Present uniform.
	11	Boots, brass-screw fastenings. Present uniform.
	12	Shoes, brass-screw fastenings. Present uniform.
	13	Buffalo overshoes. Present uniform.
	14	Arctic overshoes. Present uniform.
	15	Pair of brass-screwed shoes after nine months' constant wear by a soldier.
	16	Display of chevrons of the various arms and grades of the service; also service stripes.
	17	Display of brass ornaments (badges, letters, numbers, &c.) to denote corps, regiment, company, &c.
	18	Lithograph print of the various army corps designating badges (war of 1861–1865).
	19	Trowsers stripes for non-commissioned officers of the various arms and grades.
	20	Medal of merit of diploma awarded to the Quartermaster's Department of the United States Army at the Vienna Exhibition, 1873.
II.—Camp and garrison.	1	Banner of the Washington Life Guards, 1776.
	2	Flags of the war of 1812.
	3	National colors, infantry. Present regulation.
	4	National colors, artillery. Present regulation.
	5	Regimental colors, infantry. Present regulation.
	6	Regimental colors, artillery. Present regulation.
	7	Collection of flags designating the different army corps and divisions (late war) forming decoration over center of Quartermaster's Department exhibit.
	8	Color belt and sling. Present regulation.
	9	Infantry drum (complete). Present regulation.
	10	Artillery drum (complete). Present regulation.
	11	Fife. Present regulation.
	12	Trumpet, with cords and tassels, cavalry. Present regulation.
	13	Bugle, with cords and tassels, infantry. Present regulation.
	14	Bugle, with cords and tassels, artillery. Present regulation.
	15	Sibley tent, complete. Present regulation. } On grounds in rear of hospital.
	16	Hospital tent, complete. Present regulation. } On grounds in rear of hospital.
	17	Wall tent, complete. Present regulation. } On grounds in rear of hospital.
	18	Common tent, complete. Present regulation } On grounds in rear of hospital.
	19	Shelter tent, complete. Present regulation. } On grounds in rear of hospital.
	20	Model of Sibley tent.
	21	Model of hospital tent.
	22	Model of wall tent.
	23	Model of common tent.
	24	Model of shelter tent.
	25	Iron bunk. Present regulation.
	26	Bedsack. Present regulation.
	27	Pillow case. Present regulation.
	28	Mosquito bar. Present regulation.
	29	Woolen blanket. Present regulation.
	30	Rubber blanket. Present regulation.
	31	Rubber poncho. Present regulation.
	32	Felling-ax and sling. Present regulation.
	33	Pickax and sling. Present regulation.
	34	Hatchet and sling. Present regulation.
	35	Spade and sling. Present regulation.
	36	Shovel. Present regulation.
	37	Shovel, long handled.

Catalogue of the articles of the Quartermaster's Department on exhibition—Continued.

Class.	Number.	Articles.
II.—Camp and garrison—Continued.	38	Complete set of record books, as follows: (*a*) Brigade: Letters sent. Letters received. Indorsement and memorandum. Order. (*b*) Regimental: General order. Order. Letter. Index. Descriptive. (*c*) Company: Clothing account. Order. Descriptive. Morning report. (*d*) Post: Order. Letter. Morning report. Guard report.
	39	Box of stencil brands for marking clothing and equipage.
III.—Means of transportation.	1	Complete set of four-horse ambulance harness.
	2	Complete set of six-mule wagon harness.
	3	Complete set of four-mule wagon harness.
	4	Pack-saddle.
	5	Aparejo, species of pack-saddle of Mexican origin.
	6	Curry-comb.
	7	Horse brush.
	8	Wagon whip.
	9	"Rucker" ambulance.
	10	New Army ambulance.
	11	The "Ekin" ambulance.
	12	Paymaster's escort wagon.
	13	Army wagon.
	14	Traveling forge.
	15	Historic wagon.
IV.—Manufacturing apparatus and miscellaneous articles.	1	Machine for cutting clothing (Warth's patent).
	2	Cloth-testing machine (designed by General Meigs).
	3	Brass-screw machine, for boots and shoes.
	4	Complete set of saddler's tools.
	5	Portable forge.
	6	Complete set of farrier's tools.
	7	Hydro-dioptric light (General Meigs's patent).
	8	Regulation padlocks for store-houses, &c. (six sizes).
V. Veterinary.....	1	"Sander's" veterinary chest.
	2	Collection of horse and mule shoes used in the Army, as follows: (*a*) Burden's. (*b*) Schoenberger's. (*c*) Goodenough's.
	3	Exhibit of the United States Army system of horseshoeing, under charge of Chief Farrier John Kiernan. Specimens as follows: (*a*) Various horseshoes. (*b*) Set of farrier's tools made by hand at the cavalry instruction school, Saint Louis, Mo. (*c*) Collection of hoofs showing diseases arising from improper shoeing. (*d*) Specimens of hoofs shod with various styles of shoes, and hoofs prepared to receive shoes. (*e*) Specimens showing abnormal growth of bony deposits on the wings of "os pedis." (*f*) Specimens showing bony spavin and splint. (*g*) Skeleton of horse, complete. (*h*) Specimens of horse legs, ligaments and tendons attached. (*i*) Injected preparation showing arteries, veins, nerves, and tendons of leg (in glass case).

THE MEDICAL DEPARTMENT.

BVT. LIEUT. COL. J. J. WOODWARD,

ASSISTANT SURGEON U. S. ARMY,

IN CHARGE OF MEDICAL SECTION, WAR DEPARTMENT PARTICIPATION.

HISTORY AND PRESENT ORGANIZATION OF THE MEDICAL DEPARTMENT OF THE ARMY.

The history of the Medical Department of the Army commences with the siege of Boston, in 1775, and the first legislation by the Continental Congress had special reference to the army under General Washington before that city. By the act of July 27, 1775, Congress appointed, in addition to the medical officers of regiments and battalions already in service, a medical staff, to consist of one Director-General and Chief Physician, four surgeons, one apothecary, and twenty surgeon's mates. Dr. Benjamin Church was elected by Congress to be Director General. He was removed on a charge of treasonable correspondence with the enemy in October, 1775, and Dr. John Morgan, of Philadelphia, elected to succeed him.

As the theater of war widened it became necessary to extend this organization, and accordingly the medical staff was reorganized by the act of April 7, 1777, which created "one Director-General of all the military hospitals which shall be erected for the Continental Army in the United States," two Deputy Director-Generals, and three assistant deputy directors for each of the three districts or departments into which the theater of war was divided.

This act further created a Physician-General, Surgeon-General, and Apothecary-General, and such a number of senior physicians and surgeons, of second surgeons, and of surgeon's mates as the Director-General or the Deputy Director-General of the district should direct. Beside this staff, each regiment had its regimental surgeon and two surgeon's mates, and the act provided that there should be one Physician-General and one Surgeon-General for each separate army, to supervise the regimental medical officers. Dr. William Shippen, of Philadelphia, was appointed Director-General under this act.

July 21, 1780, the medical staff was again reorganized on the following basis: One Director of the Military Hospitals, three Chief Hospital Physicians, who shall also be surgeons; one Chief Physician, who shall also be a surgeon, to each separate army; fifteen hospital physicians, who shall also be surgeons; twenty surgeon's mates for the hospitals; one purveyor, with one assistant; one apothecary; one assistant apothecary; and "to each hospital a steward, a matron, orderly-men, and nurses as heretofore." This, in addition to the regimental surgeons

and surgeon's mates. Dr. William Shippen was re-elected Director-General under this act. He resigned January 3, 1781, and was succeeded by Dr. John Cochran, of New York.

The officers of this Revolutionary medical staff had no military rank, but by the act of October 27, 1780, they were allowed subsistence, &c., on the following scale: Director-General the same as colonel; Deputy Director-Generals, Physician-Generals, Surgeon-Generals, and Apothecary-Generals, the same as lieutenant-colonels; senior physicians and surgeons the same as majors; junior physicians and apothecaries the same as captains; surgeon's mates the same as ensigns.

In 1783 the Revolutionary army was disbanded, and the medical officers returned to their homes. Soon after, however, it became necessary to raise a small body of troops for the protection of the frontier, and to these troops regimental surgeons and surgeon's mates were assigned. April 12, 1808, the President of the United States was further authorized to appoint "such a number of hospital surgeons and surgeon's mates as the service may require, but not exceeding five surgeons and fifteen mates."

The war of 1812 rendered a further increase necessary, and March 3, 1813, the offices of "Physician and Surgeon-General, and Apothecary-General" were created. Dr. James Tilton, of Delaware was appointed Physician and Surgeon-General. These offices were abolished after the close of the war, when the army was reduced to ten thousand men, and it was provided by the act of March 3, 1815, that the number of hospital surgeons should not exceed five, with fifteen mates, there being, besides, one regimental surgeon and two mates allowed to each regiment.

May 14, 1818, the office of Surgeon-General was created by act of Congress, and the medical corps, which had undergone various changes since 1815, now consisted of one Surgeon-General, two Assistant Surgeon-Generals, one Apothecary-General, with two assistants, and forty post surgeons, with one regimental surgeon and two mates to each regiment. Dr. Joseph Lovell, of Massachusetts, was appointed Surgeon-General under this act.

The medical corps was again reorganized by the act of March 2, 1821, which abolished the offices of Assistant Surgeon-General, Apothecary-General, regimental and post surgeons, and provided that the Medical Department should consist of one Surgeon-General, eight surgeons, and forty-five assistant surgeons. In carrying out this act Dr. Lovell was continued as Surgeon-General; the surgeons were appointed from the regimental surgeons, and the assistant surgeons from the post surgeons and regimental surgeon's mates.

June 28, 1832, four surgeons and ten assistant surgeons were added to the medical corps. June 30, 1834, Congress passed a bill "increasing and regulating the pay of the surgeons and assistant surgeons of the Army," which provided that surgeons should receive the pay and

emoluments of majors; assistant surgeons, after five years' service, the pay and emoluments of captains, and assistant surgeons of less than five years' service, the pay and emoluments of first lieutenants. The bill further provided that no person should be appointed assistant surgeon, and no assistant surgeon promoted to be surgeon, except after examination and approval by an Army Medical Board. July 4, 1836, three surgeons and five assistant surgeons were added to the medical staff. October 17, 1836, Surgeon-General Lovell died and was succeeded by the senior medical officer of the Army, Surgeon Thomas Lawson, of Virginia.

July 5, 1838, Congress provided that medical officers "shall receive the pay and emoluments of officers of cavalry of the same grades, respectively, according to which they are now paid by existing laws." The same act increased the medical corps by seven additional surgeons, and provided that hospital stewards at posts of more than four companies should have the pay and emoluments of sergeants of ordnance; at all other posts those of sergeants of infantry.

August 23, 1842, the medical corps was diminished by abolishing two surgeoncies and ten assistant surgeoncies, and it continued on this basis till the Mexican war.

February 11, 1847, the corps was increased by two surgeons and twelve assistant surgeons, and ten additional regiments having been raised "for the war," the appointment of one surgeon and two assistant surgeons for each was also authorized. The act of February 11 further provided—

> That the rank of officers of the Medical Department of the Army shall be arranged on the same basis which at present determines the amount of their pay and emoluments: *Provided*, That the medical officers shall not, in virtue of such rank, be entitled to command in the line or other staff departments of the army.

By this act actual military rank was for the first time conferred by law on the officers of the medical staff.

March 2, 1849, ten assistant surgeons were added to the medical corps. August 16, 1856, four surgeons and eight assistant surgeons were added.

On the 1st of January, 1861, the medical corps consisted of one Surgeon-General, thirty surgeons, and eighty-three assistant surgeons. Surgeon-General Lawson died May 15, 1861, and was succeeded by Surgeon Clement A. Finley, of Ohio, the senior surgeon of the army. August 3, 1861, Congress passed an act by which ten surgeons and twenty assistant surgeons were added to the medical staff, and a corps of medical cadets, not to exceed fifty, was created, to be composed of young men of liberal education, students of medicine, between the ages of eighteen and twenty-three, who were to enlist for one year, and to "have the same rank and pay as the military cadets at West Point."

The great volunteer armies which took the field during the summer and fall of 1861 were provided with regimental surgeons and assistant surgeons, and a large staff corps of surgeons and assistant surgeons of

volunteers was created in the volunteer army; but the medical corps of the regular army was not further augmented until the spring of 1862. April 16, 1862, Congress passed a bill reorganizing the medical corps of the army, so as to make it consist of one Surgeon-General, with the rank, pay, and emoluments of a brigadier-general; one Assistant Surgeon-General, and one Medical Inspector-General, with the rank, &c., of colonel of cavalry; eight medical inspectors, with the rank, &c., of lieutenant-colonel of cavalry; fifty surgeons, with the rank, &c., of majors of cavalry; one hundred and forty assistant surgeons, with the rank, &c., of first lieutenants when first appointed, and the rank, &c., of captains after five years' service; and seventy medical cadets, with the rank, &c., of cadets at the Military Academy.

Under the provisions of this act Assistant Surgeon William A. Hammond was appointed Surgeon-General. May 19, 1862, the appointment of six medical storekeepers, with the rank of captain, was authorized. December 27, 1862, eight additional medical inspectors were added to the medical corps. August 20, 1864, Surgeon-General William A. Hammond was dismissed the service by sentence of a general court-martial. He was succeeded by Medical Inspector-General Joseph K. Barnes, of Pennsylvania, who, since September 3, 1863, had been serving as Acting Surgeon-General. February 23, 1865, Congress passed a bill which provided that the medical director of an army in the field, consisting of two or more army corps, and the medical director of a military department in which there are United States general hospitals containing four thousand beds and upwards, shall have the rank, &c., of colonels of cavalry; other medical directors the rank, &c., of lieutenant-colonels of cavalry.

After the close of the war the bill fixing the military peace establishment of the army, which became a law July 28, 1866, established the Medical Department on the following basis: One Surgeon-General, rank, &c., of brigadier-general; one Assistant Surgeon-General, rank, &c., of colonel; one chief medical purveyor and four assistant medical purveyors, with the rank, &c., of lieutenant-colonels; sixty surgeons, rank, &c., of majors; one hundred and fifty assistant surgeons, rank, &c., of captains of cavalry after three years' service, of first lieutenants of cavalry when first appointed; and five medical storekeepers, with the rank, &c., of captains. March 3, 1869, new appointments and all promotions in the medical corps were forbidden until further legislation, by a clause attached to the army appropriation bill.

The foregoing facts and dates are taken from a history of the Medical Department of the army compiled by Assistant Surgeon Harvey E. Brown, U. S. A., which was published by the Surgeon-General's Office in 1873.* To this work the reader is referred for further details.

*Historical Notes concerning the Medical Department of the United States Army from 1775 to 1873. Compiled under the direction of the Surgeon-General, by Harvey E. Brown, Assistant Surgeon, U. S. Army. Washington, D. C., Surgeon-General's office, 1873, pp. 314, 8 vo.

Since the publication of this work the status of the medical corps has been materially modified by two important acts. The first was the act approved June 23, 1874, entitled "An act to reorganize the medical staff corps of the army." The fourth section of this act provides that the Medical Department of the Army shall hereafter consist of one Surgeon-General, one Assistant Surgeon-General, one chief medical purveyor, two assistant medical purveyors, fifty surgeons, one hundred and fifty assistant surgeons, and four medical storekeepers. The rank of all these officers remained the same as under the law of July 28, 1866, except that the chief medical purveyor was given the rank of colonel instead of lieutenant-colonel.

The eighth section of the same act repealed the provision of the act of March 3, 1869, prohibiting appointments and promotions; but by the reduction of two medical purveyors and ten surgeons, effected by the act, all vacancies existing in the medical corps were legislated out of existence except those among the assistant surgeons at the foot of the list. The condition of the medical corps with regard to promotion was now very unsatisfactory. There were in the corps a number of surgeons of thirty, and even forty years' service, with the rank of majors only, and without hope of further promotion; and a number of assistant surgeons who had served as such from ten to thirteen years who were now deprived of any prospect of becoming surgeons in any reasonable time. The war of 1861–'65 had brought comparatively rapid promotion to every other staff corps and to the line of the army, but the officers of the medical corps, who had shared all the labors and perils, had enjoyed none of these advantages, and could not avoid a feeling of discouragement at their prospects.

Under these circumstances the officers of the medical corps, and their friends in the medical profession, cannot but accept with satisfaction the act of Congress approved June 26, 1876, which, while reducing the number of assistant surgeons to one hundred and twenty-five, and abolishing the office of medical storekeeper, adds to the corps four surgeons with the rank of colonel, and eight surgeons with the rank of lieutenant-colonel, to be promoted by seniority from the medical officers of the army. This act places the officers of the medical corps on a footing with regard to rank approximating that of the rest of the army, and while bestowing deserved promotion on a comparatively small number of medical officers gives to the junior officers something to look forward to. The reduction in the number of assistant surgeons, and the abolition of the office of medical storekeeper, can work no injustice, because the act provides that no officer now in service shall vacate his commission because of its provisions. It is hoped that this act will obviate the growing reluctance to apply for admission to the medical corps, exhibited of late years by the better class of young medical men, and that as vacancies among the assistant surgeons occur hereafter there will be no difficulty in filling them with competent officers.

As at present fixed by law, then, the medical corps of the army consists of the following grades: One Surgeon-General, with the rank, &c., of brigadier-general (the present incumbent is General J. K. Barnes); one Assistant Surgeon-General, with the rank, &c., of colonel (the present incumbent is Col. C. H. Crane); one chief medical purveyor, with the rank, &c., of colonel (the present incumbent is Col. J. H. Baxter); four surgeons, with the rank, &c., of colonel; two assistant medical purveyors, with the rank, &c., of lieutenant-colonels; eight surgeons, with the rank, &c., of lieutenant-colonels; fifty surgeons, with the rank, &c., of majors; one hundred and twenty-five assistant surgeons, with the rank, &c., of first lieutenants of cavalry when first appointed, and of captains of cavalry after five years' service. There are besides four medical storekeepers, with the rank of captains, but it is provided by the act of June 26, 1876, that vacancies occurring hereafter in this grade are not to be filled.

Under existing laws and regulations the Surgeon-General is charged with the direction and supervision of all the operations of the Medical Department of the Army, and is aided in these duties by the Assistant Surgeon-General. The chief medical purveyor is charged, under the Surgeon-General, with the purchase and distribution of all medical and hospital supplies, and is aided in these duties by the assistant medical purveyors. In each military department one surgeon is detailed to act as medical director. He is a member of the staff of the general commanding the department, and is the medium of communication between the commanding general and the medical officers serving in the department, as well as between these officers and the Surgeon-General. He is charged with the general supervision of all medical and surgical affairs within the department under his direction; requisitions for medical supplies for any post in the department require his approval, and the medical and surgical reports are sent by the medical officers to the Surgeon-General through him. He receives no additional rank or compensation for these duties beyond the rank and pay as surgeon. The other surgeons and assistant surgeons are for the most part stationed at the several military posts, where they perform the duties of post surgeons. The number of posts and stations is so large that usually but one medical officer is stationed at each. Indeed, the number of posts and stations is larger than the number of commissioned medical officers, so that it has been found necessary to employ by contract a number of civil physicians, who are known as acting assistant surgeons. The medical officer at each military post, whatever his rank, is directly subordinate to the commanding officer of the post.

During the war of 1861–'65 medical officers were assigned to duty as the commanding officers of the general hospitals; but at present no general hospitals exist in the Army, the sick of each military post being cared for in the post hospital.

No person can be appointed an assistant surgeon in the army except

after examination and approval by a medical board, and a second examination is required before promotion to the grade of surgeon. All promotion in the medical corps is by seniority, except in the case of the Surgeon-General, who is appointed by selection.

Besides the medical officers, there are attached to the Medical Department as many hospital stewards "as the service may require." These are selected from among the enlisted men of the Army, or may be specially enlisted for this duty. Hospital stewards are graded in three classes; those of the first class are appointed by the Secretary of War, and receive warrants as non-commissioned officers with the rank, &c., of sergeants of ordnance. The number of this class at present in service is two hundred and twenty-four. Those of the second class are detailed from the enlisted men of the command, on the recommendation of the medical officers, by the commanding officer of a post or detachment of more than four companies. Those of the third class are similarly detailed at posts, or with detachments of four companies or less. The number of stewards of the second and third classes now in service is thirteen. At present, in most instances, there is but one hospital steward at each post. He has, under the direction of the post surgeon, immediate charge of the discipline and management of the hospital, acts as clerk and apothecary, supervises the cooking, &c.

The nurses and other hospital attendants are generally enlisted men detailed for the purpose by the post commander. Nurses are allowed on the basis of one to every ten patients. Medical officers are required to make monthly statistical reports of the sick and wounded under their charge to the Surgeon-General. They also make special reports of surgical operations and interesting medical cases. Sanitary reports of the several posts are forwarded annually. Meteorological instruments are furnished to such posts as are designated by the Surgeon-General, observations recorded and monthly reports made. The various reports are examined and studied at the Surgeon-General's office by medical officers detailed for the purpose. The results not merely serve to keep the Surgeon-General acquainted with the condition and needs of his department, but are the basis of a series of medical and surgical publications, which have been accepted as valuable, not merely by the medical officers of the army but by the medical profession generally.

The Army Medical Museum and the library of the Surgeon-General's office (National Medical Library) are indispensable aids to the intelligent discussion of the reports collected. They have already proved to possess a wider field of usefulness, which it is hoped will be still further extended in the future.

CATALOGUE

OF THE

EXHIBIT OF THE MEDICAL DEPARTMENT, UNITED STATES ARMY, AT THE INTERNATIONAL EXHIBITION, 1876.

The exhibit of the Medical Department of the United States Army in the International Exhibition of 1876 is intended to represent, in as comprehensive a manner as possible, the character of the work of the medical staff in peace and war. It will represent four classes of objects, either by the objects themselves, by models, or by photographs.

CLASS I. The hospitals in which sick and wounded soldiers are treated. These are represented by—

(*a*.) A post hospital for twenty-four beds of full size, as described below.

(*b*.) Three full-sized hospital tents, pitched end to end, with furniture complete, representing the tent ward which served as a unit, the multiplication of which produced "tent field-hospitals" used during the war of 1861–'65.

(*c*.) Models of the barrack "general hospitals" used during the war of 1861–'65, viz: A model of the form of barrack ward for sixty beds, found most efficient during the war, worked out in all details on the scale of half an inch to the foot (about 7 feet long), and four ground-plan models, showing some of the different ways in which such wards were combined in constructing general hospitals. These latter models are about 4 feet square, with the wards 6 inches long.

CLASS II. The medical and hospital supplies employed in the treatment of sick and wounded soldiers in the field and in hospital. These are represented by a full set of samples of all the articles on the medical supply table of the army, consisting of (*a*) medicines, (*b*) hospital stores, (*c*) surgical instruments and dressings, (*d*) hospital furniture, bedding, clothing, and appliances, (*e*) books, blank forms for reports, and stationery.

Under this head is also represented (*f*) medicine panniers and medicine wagons, and (*g*) samples of the artificial arms, legs, trusses, and other apparatus issued by the Medical Department (in accordance with acts of Congress) to disabled soldiers.

CLASS III. Means of transporting sick and wounded soldiers. This subject is represented by (*a*) stretchers and litters, full size and models; (*b*) several full-size ambulances and small models; (*c*) five models of hospital railroad cars, such as were used during the war of 1861–'65, on the

scale of an inch to the foot, with all details perfectly worked out; (*d*) model of the hospital steamboat, on the scale of one-fourth of an inch to the foot, illustrating the method of transporting the sick and wounded employed on the western rivers during the war; (*e*) model of a hospital ocean steamship, on the scale of three eighths of an inch to the foot, illustrating the mode of transporting the sick and wounded employed on the Atlantic coast during the war.

CLASS IV. Methods employed for the systematic study of the diseases and injuries of soldiers, with a view to their more efficient treatment. Under this head (*a*) the Army Medical Museum is represented by selected medical, surgical, anatomical, and microscopical specimens, numerous photographs of such specimens, and the printed catalogues of the museum. (*b*) The library of the Surgeon-General's office is represented by its catalogue, and by photographs of the title-pages of rare books on military medicine and surgery, &c. (*c*) A full set of the medical and surgical publications of the Surgeon-General's Office.

The articles embraced in the exhibit thus classified are for the most part displayed in the wards and other rooms of the post hospital (Class I, *a*). The hospital tents are pitched in the grounds immediately behind its north wing, and still further to the rear the full-size ambulances and medicine wagons are parked in line.

DESCRIPTION OF THE REGULATION POST HOSPITAL FOR TWENTY-FOUR BEDS.

(CLASS I, *a*.)

In time of peace the little army of the United States, consisting of some 25,000 men, is scattered over a vast extent of territory, and distributed in about two hundred permanent or temporary posts and garrisons.

The close of the war of 1861–'65 found a portion of these posts provided with hospitals of the old style in use before the war, while in others wooden barrack hospitals had been constructed during the war, and at others, which had just been occupied, hospitals had yet to be constructed.

In order to secure uniformity in the plan of hospital construction at the new posts, and with the view of gradually replacing the older structures by more suitable buildings, a plan for the construction of post hospitals was prepared at the Surgeon-General's Office, which was rendered authoritative by an order issued by the War Department, by Secretary E. M. Stanton, April 22, 1867. (Circular No. 4, Surgeon-General's Office, April 27, 1867.)

According to this plan post hospitals were to be constructed with twelve, twenty-four, or forty-eight beds. The twenty-four bed hospital was the unit of the system. It consisted of a central administration building two stories high, with a one-storied back-building for the

kitchen, and two one-storied wings as wards; each ward was to accommodate twelve beds, and was to be 33 feet long by 24 wide, inside measure; 15 feet high in the clear from floor to eaves; with ridge ventilation for summer, and shafts, like those used in the war hospitals for winter ventilation. The twelve-bed hospital was constructed on the same plan, except that one ward was omitted. The forty-eight-bed hospital was also to be constructed on the same plan, except that the wings were to be lengthened, making each ward 66 feet by 24 in the clear, and to contain twenty-four beds each. The administration building was to remain the same in each of the three cases. These plans aimed at the extremest economy consistent with securing the application of those principles of hospital construction which experience during the war of 1861–'65 had shown to be desirable.

A number of hospitals were built in accordance with these plans, but it was thought on trial that they erred somewhat in the direction of extreme economy, and various minor alterations and improvements were suggested by the medical officers who superintended their construction and use, in consequence of which the Surgeon-General directed new and somewhat more eleborate plans to be prepared. These were approved by the Secretary of War, and issued as Circular No. 2, of the Surgeon-General's Office, July 27, 1871. This circular gave plans and specifications for three classes of hospitals:

1. *Regulation post hospital of twenty-four beds*, constructed on nearly the same plan as the twenty-four bed hospital of the former circular, but with larger apartments, with a veranda surrounding the building, and other improvements and modifications. This form of hospital is that described below.

2. *Regulation post hospital of twelve beds.*—This is a two-story building, with rooms for administrative purposes on the first floor and a ward of twelve beds in the second story.

3. *Provisionary hospitals.*—The circular also gave ground plans for provisionary hospital of twelve beds, one plan representing a one-story building, the other representing a two-story building with the ward in the second story.

One of these regulation post hospitals for twenty-four beds has been erected on the Exhibition grounds for the double purpose of serving as a model to illustrate the plan of hospitals recommended by the Medical Department, and adopted by the War Department for our military posts in time of peace, and of affording space for the greater portion of the other articles exhibited by the Medical Department.

The regulation post hospital for twenty-four beds is a frame building, with shingle roof, surrounded by a veranda, and constructed in accordance with the plans and specifications of the circular of July 27, 1871.

Fig. 1 is a front view; Fig. 2, the floor plans.

It consists of a central administration building, 35 feet front by 39 deep, and two stories high, with a two-storied back building 40 by 14

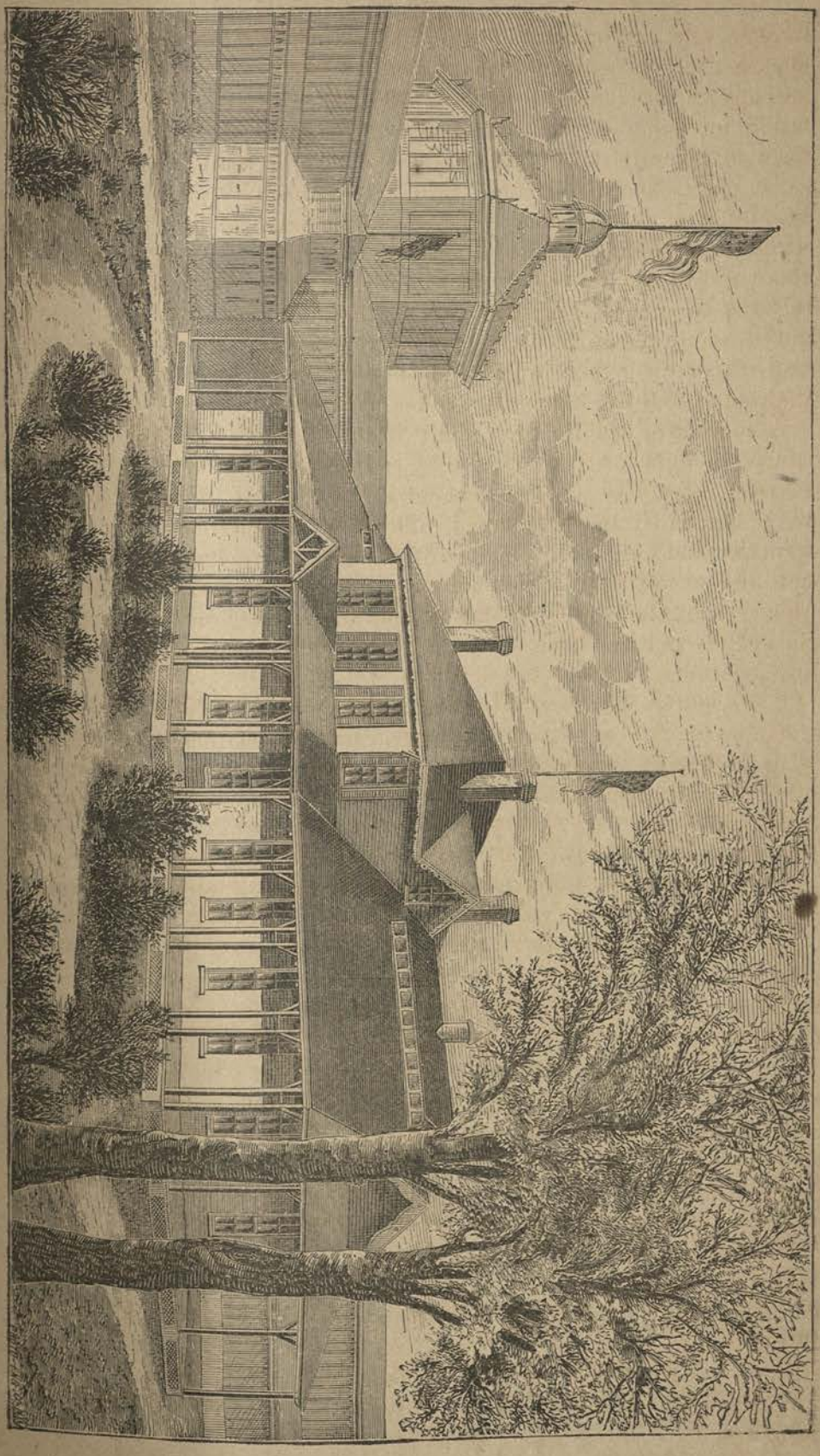


FIG. 1.—Regulation post hospital for twenty-four beds, front view.

feet, and two wings 45 feet by 24, one for each ward of twelve beds. The floor of the whole building is raised 3 feet above the ground, and is well supported on timber posts. The general arrangements are shown in Fig. 2. In the plan of the ground floor, 1, 2 are the wards, each 24 by 45 feet; 3, dispensary, 14 by 15 feet; 4, office, 14 by 15 feet; 5, mess-room, 14 by 20 feet; 6, kitchen, 14 by 14 feet; 7, nurses' room, 14 by 15 feet; *a*, *b*, earth-closets, each 9 by 9 feet; *c*, bath-room and lavatory; *d*, *e*, closets; *f*, pantry, 8 by 10 feet. In the plan of the second story, 8 is the steward's room, 14 by 15 feet; 9, spare room, 14 by 15 feet; 10, attendants' room, 14 by 19 feet; 11, store-room, 14 by 15 feet; 12, room for violent patients, 14 by 20 feet. The above are all inside measurements. All the walls and ceilings are lathed and plastered with two coats, the finishing coat being plaster of Paris, and the entire woodwork usually painted is covered with two coats of paint.

The wards are 15 feet high in the clear from floor to ceiling. Ridge ventilation is provided for the summer months by means of two boxed openings in each ward, carried from the middle line of the ceiling to the ridge. These openings are 10 feet apart, and are each 10 feet long by 2½ feet wide.

In the winter months the opening at the ridge is to be closed, and ventilation effected in the following manner: A large stove is placed in the middle of the ward. Fresh air is introduced by an air-box 18 inches square, which passes underneath the floor of the ward from side to side, open at each extremity to the external air, and opens in the center of the ward beneath the stove by means of a register; when a ventilating stove is used the place of the register is occupied by a pipe, which connects the air-chamber of the stove with the air-box beneath the door.

The pipe of the stove passes up through a close-fitting collar in the ceiling. One foot above the ceiling it enters a shaft or jacket about 24 inches in diameter, which pierces the roof, and extends four feet above; it is covered with a sheet-iron cap, pierced in its turn by the stove-pipe, which is capped in the same manner. At each end of the ward, and two feet from the center, there is an opening in the ceiling one foot square, from which an air-box passes to a box inclosing the lower mouth of the shaft surrounding the stove-pipe. The heat of the stove-pipe causes a continuous upward current in this shaft, which is supplied by the vitiated air from the ward through the air-boxes.

In each of the earth-closets there is a ventilating shaft 6 inches square, and the gas-burner of the room is situated directly beneath it. These earth-closets in the regulation hospitals are intended for very sick patients only, accommodations for other patients and the attendants being provided in a suitable detached building. A small detached building is also intended to be provided for the purpose of a dead-house, and cases of small-pox and other contagious diseases are to be treated in hospital tents.

In fitting up this building for the Exhibition of 1876 the rooms numbered in Fig. 2 are occupied as follows: Room 1 is fitted up as a ward, and serves for the exhibition of hospital furniture, bedding, and cloth-

ing; room 2 serves for the exhibition of the models of hospitals, hospital steam vessels, hospital railway cars, ambulances, &c., and for specimens from the Army Medical Museum; room 3, for the exhibition of medicines, medical stores, and chemicals; room 4, for surgical instruments, books, blanks, and the publications of the Surgeon-General's Office; room 5, for mess furniture and utensils; room 6, for kitchen utensils; room 7 is the private office of the surgeon in charge; room 8 contains prothetic apparatus; room 9, medical chests, panniers, knapsacks, &c.; room 10 contains litters and stretchers; room 11 is reserved for the reception of medical visitors, and room 12 for the watchman. (See Fig. 2.)

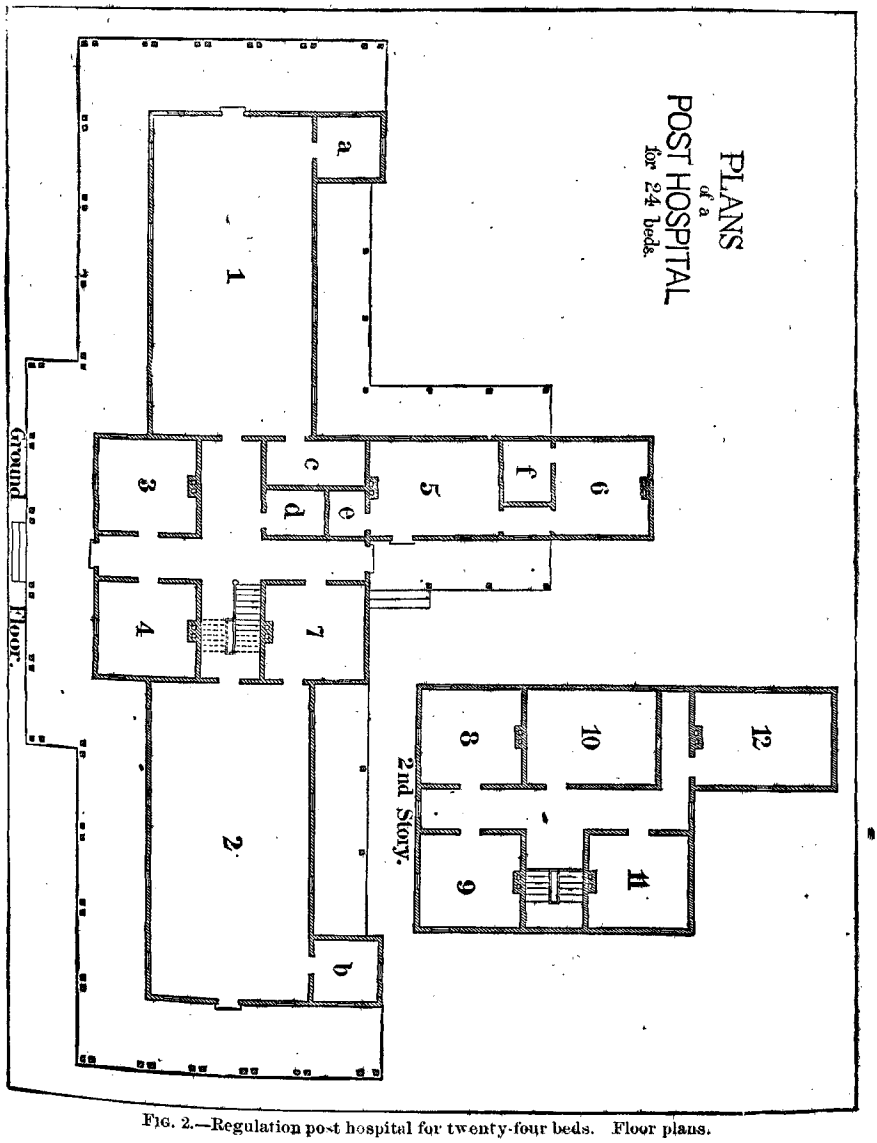


FIG. 2.—Regulation post hospital for twenty-four beds. Floor plans.

In the following enumeration of the objects exhibited the catalogue will follow the actual order of arrangement in the several rooms. The classes to which the individual articles belong will be indicated in brackets.

Room No. 1.

This room is in the south ward of the post hospital building, and is fitted up as a ward for the display of the hospital furniture, bedding, clothing, &c., as issued by the purveyor's department in accordance with the present "standard supply table" of the army.

No. 1. Eleven iron bedsteads of the pattern furnished to the medical purveyors by the Composite Iron Works Company of New York. The bedsteads have light iron frames, with T-shaped uprights to support mosquito nets, and elastic wooden slats, on which the mattresses rest.

No. 2. Crosby's invalid or fracture bedstead. This is essentially a double bedstead, the inner and smaller one being movable. The patient lies immediately upon a series of transverse pieces of webbing attached to the outer frame. The mattress and lower sheet are arranged on the inner frame, which can be elevated or lowered by means of a crank. When elevated the mattress supports the webbing and patient; when lowered a bed-pan may be used without disturbing the patient's position, or the sheet or matteress may be changed.

The several bedsteads serve for the display of the bedding ordinarily issued to post hospitals, viz: On each bed (with the exception of two, see No. 3 below) is a hair mattress, two sheets, a pair of blankets, a white counterpane, and a pillow (either hair or feathers). Each bed is provided with a white mosquito netting. On the Crosby bedstead a full-sized manikin has been placed, which serves to exhibit the hospital clothing issued by the purveyor's department, viz: Shirt, drawers, dressing gown, socks, and slippers. This manikin also serves to exhibit a mode of treating fractures of the thigh, which was extensively employed during the war of 1861–'65. In this method extension is made by a weight attached to a cord, which passes over a pulley on the foot of the bedstead and is fastened to the leg of the patient by means of two broad strips of adhesive plaster. The weight of the patient's body renders other counter-extension unnecessary, and the broken limb is retained in position by means of two long sand-bags.

A second full-sized manikin on the next bedstead serves to exhibit the application of the "anterior splint," devised by Prof. N. R. Smith, of Baltimore, for fractures of the leg, and of the splint devised for fracture of the legs by Dr. J. P. Hodgen, of Saint Louis.

No. 3. Two of the wire mattresses made by the Woven Wire Mattress Company, of Hartford, Conn., are exhibited on two of the bedsteads. A small number of these are issued to post hospitals for use in special cases.

No. 4. Twelve bedside tables of polished wood, each provided with two drawers.

No. 5. Eleven bedside chairs of polished wood, with curved backs.

No. 6. Two rocking-chairs of polished wood, iron braced.

No. 7. One eight-day clock (manufactured by the Seth Thomas Clock Company).

No. 8. Twelve rubber spittoons.

No. 9. Two bed screens, wooden frames, covered with green glazed muslin.

No. 10. Two delft spit-mugs.

No. 11. Two delft medicine spoons.

No. 12. Two delft feeding cups.

No. 13. Water-cooler, of tin, three gallons.

No. 14. Nine brown oiled-linen window-shades, with fixtures.

This room also contains a portion of the photo-micrographs from the Army Medical Museum, and a painting of Prof. Samuel D. Gross, loaned for the Exhibition by that gentleman, viz:

No. 15. An oil painting by Eakins, of Philadelphia, representing Professor Gross performing an operation for the removal of dead bone from the femur of a child, in the amphitheater of the Jefferson Medical College.

No. 16. A small photograph of the same.

On the walls are suspended nine solar enlargements, from photomicrographs made by Assistant Surgeon J. J. Woodward at the Army Medical Museum. The pictures are for the most part about 2 feet in diameter, viz:

No. 17. Body scale of gnat. A, showing transverse markings; B, showing dots, due to diffraction. Magnified 8,250 diameters.

No. 18. Navicula rhomboides. A, frustule showing transverse striæ, magnified 3,500 diameters; B, the same, showing longitudinal striæ, magnified 3,500 diameters; C, portion of the same, showing beads, magnified 9,000 diameters.

No. 19. Test podura scale (*Lepidoceptus curvicollis*). Portion of a scale; magnified 2,300 diameters.

No. 20. Test podura scale (*Lepidoceptus curvicollis*). A, scale, magnified 4,000 diameters; B, portion of a scale; magnified 6,000 diameters.

No. 21. Two views of a perpendicular section of the colon, showing inflammation of the submucosa; magnified 1,300 diameters.

No. 22. Perpendicular section of colon through the edge of an ulcer. Dysentery. Magnified 275 diameters.

No. 23. Colon, coated with pseudo-membrane. Perpendicular section. Dysentery. Magnified 275 diameters.

No. 24. Colon, showing a follicular ulcer. Perpendicular section. Catarrhal inflammation. Magnified 275 diameters.

No. 25. Colon, with ulceration of solitary glands just commencing. Perpendicular section. Catarrhal inflammation. Magnified 275 diameters.

No. 26. Colon, showing an enlarged solitary gland. Perpendicular section. Catarrhal inflammation. Magnified 275 diameters.

No. 27. Perpendicular section of ileum, showing an enlarged solitary gland. Catarrhal inflammation. Magnified 275 diameters.

The two lower panes of each window are occupied by photographic transparencies on glass, from photomicrographs made by Assistant-Surgeon J. J. Woodward at the Army Medical Museum. The circle occupied by the picture in each is about 10 inches in diameter, viz:

No. 28. (*a.*) Coscinodiscus. From Nottingham earth. 1,000 diameters. (Neg. 479.) (*b.*) Coscinodiscus. Nottingham earth. 2,200 diameters. (Neg. 480.)

No. 29. (*a.*) Epithelial cancer of leg, showing narrow cancer-cylinders and "*globules epidermiques.*" 140 diameters. (Neg. 646.) (*b.*) Epithelial cancer of leg, showing a net-work of bands on the margin of the cancer. 52 diameters. (Neg. 655.)

No. 30. Epithelial cancer of leg, showing the terminations of cancer-cylinders. 800 diameters. (Neg. 653.) (*b.*) Cysto-carcinoma of ovary. 440 diameters. (Neg. 705.)

No. 31. (*a.*) Section of medullary cancer of the parotid. 800 diameters. (Neg. 707.) (*b.*) Group of so-called cancer cells. 2,000 diameters. (Neg. 377.)

No. 32. (*a.*) Section of cartilage. 800 diameters. (Neg. 25.) (*b.*) Section of cartilage. 675 diameters. (Neg. 103, old series.)

No. 33. (*a.*) Epithelial cells of salivary corpuscles. Saliva. 2,000 diameters. (Neg. 409.) (*b.*) Section of molar tooth—human—showing branching dentinal tubes. 1,300 diameters. (Neg. 668.)

No. 34. (*a.*) Invasion of muscle by cancer. Transverse section. 800 diameters. (Neg. 670.) (*b.*) Invasion of muscle by cancer. Longitudinal section. 800 diameters. (Neg. 670.)

No. 35. (*a.*) Wandering corpuscles among epithelial cells in epithelial cancer. 1,960 diameters. (Neg. 709.) (*b.*) Cancer of breast, showing invasion of the adjacent adipose tissue. 800 diameters. (Neg. 691.)

No. 36. (*a.*) Epithelial cancer of the lip. Slice near the edge of the tumor, showing diseased labial glands. 52 diameters. (Neg. 667.) (*b.*) Shield of heliopelta. 1,000 diameters. (Neg. 397.)

Room No. 2.

This room is the north ward of the post hospital building, and contains the models of hospitals, and models representing the several methods of transporting the sick and wounded, specimens from the Army Medical Museum, &c.

MODELS OF THE BARRACK HOSPITALS OF THE WAR OF 1861-'65.

These are represented by five models, viz, a model of the barrack ward which served as the unit, by the repetition of which to the necessary extent the "general hospitals" were formed; and four models representing four of these general hospitals, viz, the Lincoln, Hicks, McClellan, and Mower hospitals. All these models are exhibited in room 2 of the post hospital building.

No. 1.—Model of a Barrack Ward.

This model was constructed by Mr. Charles Seltman, of Washington, D. C., and being on the scale of half an inch to the foot, is 7 feet 9½ inches long. All details of framing and construction are faithfully represented, except that the roof is hinged, so as to be lifted for the inspection of the interior.

The form of ward represented is that which was finally adopted by the War Department in the summer of 1864, as set forth in the following order, which is given in full because it describes not merely the barrack ward, but also the general plan of hospital construction, particular instances of which are illustrated by the four models described below:

War Department, *July* 20, 1864.

The following instructions are promulgated for the information of officers charged with the construction of general hospitals, and will be deviated from only in cases of imperative necessity: Buildings will not be taken or occupied for hospital purposes until after full examination and approval by a medical inspector, or other officer of the medical corps detailed for this purpose, and all alterations will be made in accordance with plans submitted by him and approved by the Surgeon-General.

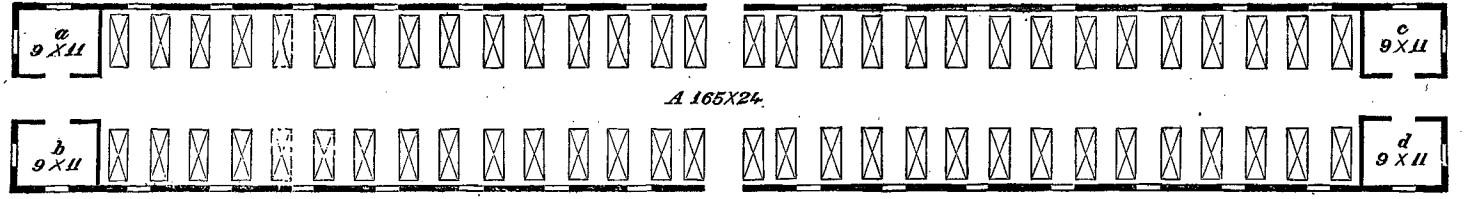
E. M. STANTON,
Secretary of War.

Site.—The site of the hospital should be a well-drained plain, with a subsoil of gravel, and sufficiently extensive to accommodate the buildings. The situation should be elevated, as remote as possible from marshes or other sources of malaria, and must have a convenient supply of pure water.

Plan.—General hospitals will be constructed on the principle of detached pavilions, each ward being in a separate building, with beds for sixty patients. Besides the wards, there will be detached buildings for each of the following purposes: General administration building, dining-room and kitchen for patients, dining-room and kitchen for officers, laundry, commissary and quartermaster's store-house, knapsack-house, guard-house, dead-house, quarters for female nurses, chapel, operating-room, and stable. The wards, administration building, kitchen, dining-rooms, and chapel are to be connected by covered walks, which will have floors, but no sides.

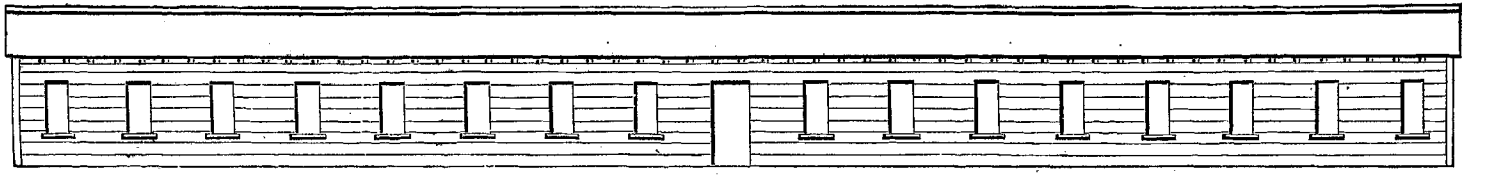
No general plan for the arrangement of the buildings can be directed, as the varying character and dimensions of sites render an uniform adherence to any one impracticable. Wards may be arranged *en échelon* in two converging lines, forming a V—in this case, the administration building should be at the apex of the V, the other buildings between the wings; or as radii from the periphery of a circle, ellipse, or rounded oblong—in this case, the administration building should be one of the radii, the other buildings within the inclosure; or parallel to each other—in this case, the administration building should be in the center of the row, the other buildings in the rear. Other plans may be rendered necessary by the special features of the ground. In any

Fig. 3



PLAN OF WARD

Fig. 4



SIDE ELEVATION

case, the important points to be observed are, to place the buildings far enough apart (at least 30 feet should intervene between two parallel buildings), and to locate them in such manner that no one shall interfere with the ventilation of another. It is preferable to locate the wards so that the long diameter may run north and south, or nearly so.

Each *ward* will be a ridge-ventilated pavilion 187 by 24 feet. At each extremity two small rooms 9 by 11 feet, one on each side of a passage, 6 feet wide, will be partitioned off. The space remaining for patients will be 165 by 24 feet (see Fig. 3, A, which gives the location of the beds and position of the doors and windows). The small rooms are occupied as follows: Fig. 3, *a*, chief nurse; *b*, closet for medicines, &c.; *c*, bath-room; *d*, closet for close stools. Fig. 4 is the side elevation.

The wards will be 14 feet high from floor to eaves, the pitch of the roof to vary in accordance to the materials composing it. The floor to be elevated at least 18 inches from the soil, with free ventilation beneath it. A ward thus constructed will accommodate sixty patients, allowing more than 1,000 cubic feet of air-space to each. The number of wards will be regulated by the number of patients the hospital is intended to accommodate. A hospital of 1,200 beds will require 20 wards.

Administration building.—For a hospital of 600 to 1,200 beds, this will be a ridge-ventilated building, 38 by 132 feet, and two stories high; the first 14 and the second 12 feet high in the clear. This building contains the general office, office of surgeon in charge, linen and store rooms, dispensary, chaplain's office, lodging-rooms for officers, &c.

Dining-room and kitchen for patients.—The dining-room will be a ridge-ventilated building, large enough to seat a number equal to two-thirds the number of beds. The most convenient form is a long parallelogram, into which the kitchen opens in the center of the long side. The kitchen will be divided into two unequal parts—the larger for the preparation of ordinary diet, the smaller for the extra diet—the cooking in both to be done on ranges. Where there is an engine, steam may be advantageously used for boiling.

Dining-room and kitchen for officers.—A small building for this purpose will be situated near the administration building.

Laundry.—A building two stories high, with lodging for the laundresses on the second floor. The roof should be flat, with posts for stretching clothes-lines.

Commissary and quartermaster store-room.—A small two-story building, furnished with boxes and shelves for the various parts of the ration—having an ice-house connected with it for the preservation of meats and other perishable articles, and a room for clothing. The second story to contain lodging-rooms for the cooks.

Knapsack house.—A building to receive the effects of the patients while in hospital. It will contain as many pigeon-holes, each 2 feet square, as there are beds in the hospital.

Guard-house.—A detached building to lodge the guard, with a guard-room for prisoners.

Dead-house.—A small building containing two apartments, located so as not to be observed from the wards, and lighted by sky-lights.

Quarters for female nurses.—A detached building containing lodging-rooms, dining-room, and kitchen for the female nurses.

Chapel.—A detached building, fitted for the purpose of religious services, so arranged as to be used also as a library and reading-room.

Operating-rooms.—Two rooms, each 15 feet square; one well lighted by sky-lights, the other by windows. The first for surgical operations, the second for discharge-boards, &c. It should be situated near the administration building.

Stable.—For ambulance and officers' horses.

Water supply.—Where practicable, a large tank will be erected and kept supplied from wells or springs by pumps worked by a steam-engine. The engine, if possible, will be situated near the kitchen and laundry, in which case the steam may be made

serviceable in cooking, and the power may be employed in working the washing and mangling machines.

Sinks.—Where the supply of water is adequate water-closets may be constructed in one of the small rooms in each ward; but where this is not the case privies will be built at a convenient distance from the wards, furnished with water-tight boxes, which must be emptied every night.

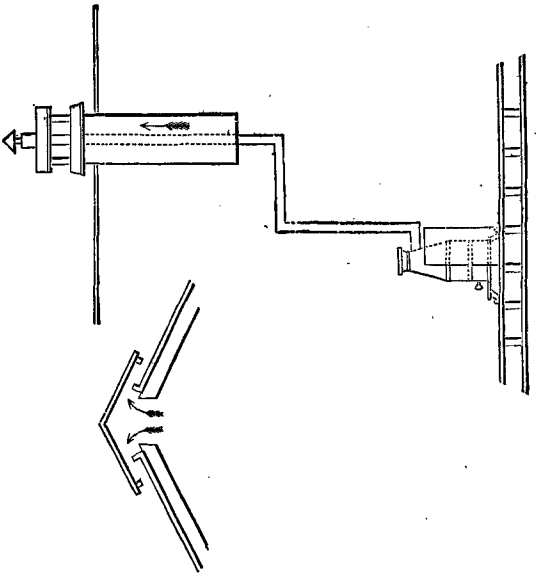


FIG. 7.

FIG. 6.

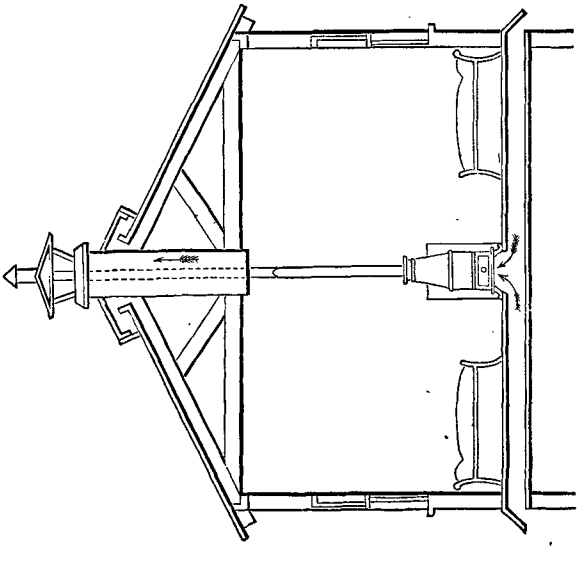


FIG. 5.

Ventilation.—During warm and mild weather the wards will be ventilated by the ridge (Figs. 5 and 6), but during winter the ridge will be closed (Fig. 7), and ventilation by shafts substituted. Four stoves will be allowed to a ward, each partly sur-

rounded by a jacket of zinc or sheet-iron, with an air-box opening beneath it to furnish the supply of fresh air. At 8 feet from the stove will be a shaft, properly capped, through which the stove-pipe will ascend. Fig. 8 gives a section and Fig. 9 a side view of the arrangement. The shaft should be 18 inches square, and should not come below the tie-beams.

No. 2.—Model of the Lincoln Hospital, Washington, D. C.

This is a block model, on the scale of 30 feet to the inch, and represents the arrangements of the wards and other buildings of this hospital, of which the following description was furnished by Surgeon J. C. McKee, U. S. A., who was for a long time in charge:

Lincoln Hospital, Washington, D. C., is located about a mile east of the Capitol building. Its site is a gently undulating, uncultivated plain, without shade-trees. East and south of the hospital the plain declines towards the Eastern Branch of the Potomac, which is about half a mile distant. The soil is a light sandy loam, resting on a deep stratum of gravel. The hospital covers an area of 30 acres of ground, and consists of twenty detached pavilion wards, arranged *en echelon* in the shape of the letter V, the apex of which looks westwardly. The administration building is at the apex of the V. The buildings for kitchen, dining-rooms, &c., are in the space between the two sides of the letter. The whole is surrounded by a picket-fence, five feet high, between which and the wards is a wide road for ambulances. (See Fig. 8.)

The *wards* are pavilion barracks, built of rough boards, white-washed, with roofs of boards covered with tarred paper; they are twenty in number, ten on each wing. Each ward is 187 by 24 feet, 16 feet to the eaves and 20 to the ridge, at which there is the usual ridge-ventilation the whole length of the ward. They are plastered on the inside for about 8 feet above the floor. At the west end of each are four rooms, occupying 15 feet in length. These are used for clothing, baths, nurses, and sinks. Each ward contains thirty-four windows and four doors, one at each end and two in the middle, opposite each other. Four ventilating gratings, at regular distances in the floor of the ward, communicate by wooden flues under the floor with the air outside, thus giving a full supply of fresh air whenever the weather requires the doors and windows to be closed. With sixty-two patients, there are 72 square feet of floor and 1,447 cubic feet of air-space for each. Thirty-one beds are arranged on each side, with a chair and bed-side table between each pair. An avenue of 11 feet is left between the two rows of beds. The wards are lighted at night by kerosene lamps, and heated by stoves in winter. On the inner side of the two wings of the hospital, and running the whole length of each, is a raised covered walk or corridor, on which is laid a railway track 2 feet wide and 2,156 feet long. Box-cars convey the food from the main and extra kitchens to each ward.

The *administration building*, at the apex of the triangle, is 184 by 38 feet, 22 feet to the ridge and 16 to the eaves. A hall, 8 feet wide, runs the entire length of the first floor. On the left side of the hall are the following rooms: Office of surgeon in charge, 14 by 14; office of military assistant, 11 by 14 (employs two clerks); principal office, 56 by 14 (employs fourteen clerks); printing-office, 19 by 14 (employs two men); quartermaster's store-room for clothing, &c., 44 by 14 (employs two clerks); wardmaster's room, 13½ by 14; bath-room, 4¾ by 14; post-office, 7 by 14 (employs a postmaster and assistant). On the other side of the hall, and on the right of the entrance door, are the office of the officer of the day, 15 by 14; office of the officer of the guard, 11 by 14 (four clerks); office of surgical records, 11 by 14 (one clerk); private office of surgeon in charge, 12½ by 14; office of medical inspector, 11 by 14; linen-room, 66 by 14; all washed clothing and bed-linen is sent from the laundry to this room, and thence distributed to the different wardmasters; one clerk and four women are employed here, the latter in mending, &c. The medical store-room, 11 by 14, adjoins

the dispensary, and is used for storing supplies. The dispensary, 25 by 14, usually employs four men; the medicines for the whole hospital are compounded here, under the charge of a hospital steward. Lastly, the laboratory, which adjoins the dispensary, is 22 by 14 feet, used for preparing tinctures, ointments, plasters, &c.

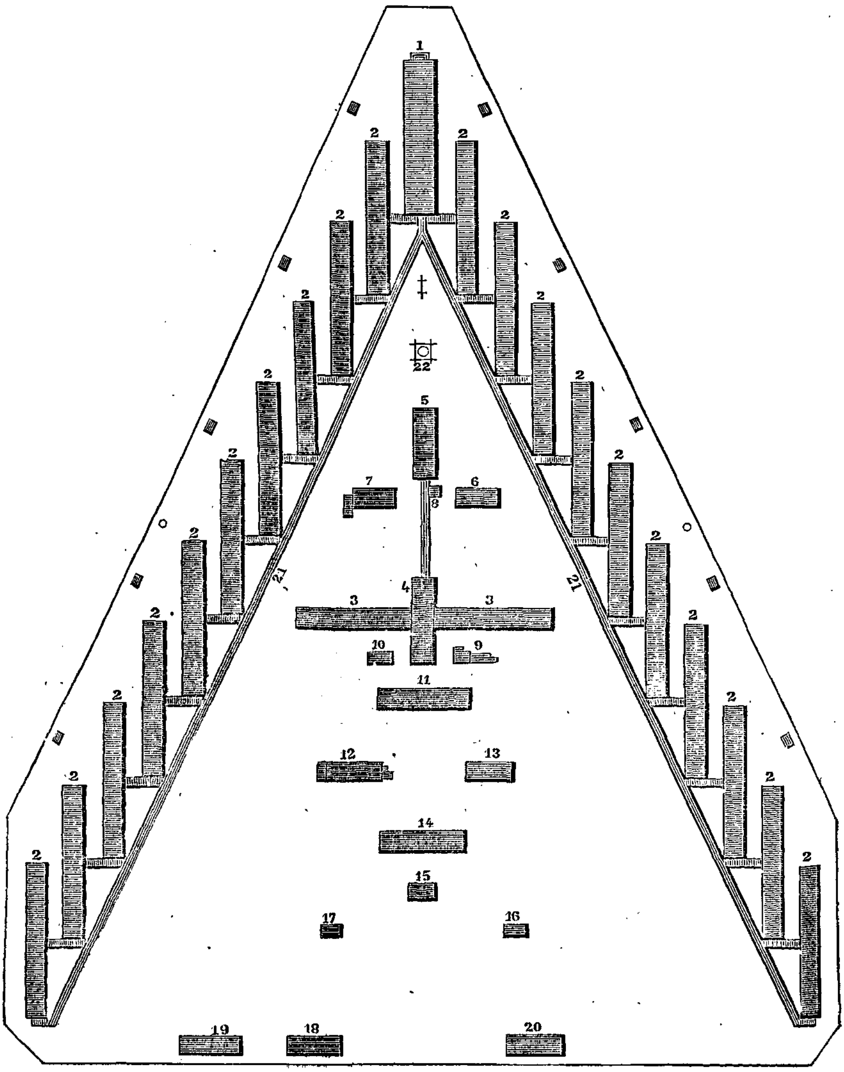


FIG. 8.—GROUND PLAN OF LINCOLN GENERAL HOSPITAL, WASHINGTON, D. C. Scale, 200 feet to the inch. 1, Administration building. 2 2 2 2, Wards. 3 3, Dining-rooms. 4, Kitchen. 5, Laundry. 6, Steward's quarters. 7, Sisters' quarters. 8, Engine-house. 9, Meat-house. 10, Coal-house. 11, Commissary building. 12, Sutler. 13, Chapel. 14, Stable. 15, Freedmen's quarters. 16, Guard-house. 17, Dead-house. 18, Barracks for guard. 19,20, Officers' quarters. 21, Covered way. 22, Tank.

On the second floor of the administration building is the knapsack-room, 111 by 37 feet. The effects, accouterments, &c., of the patients coming into the hospital are deposited in this room for safe keeping. It employs two men, who receive the articles deposited, issue tickets for the same, credit them to depositors, and deliver

them when the patients leave. There are 2,184 boxes, arranged in parallel rows, reaching from the floor to the ceiling. Adjoining the knapsack-room is the extra-duty men's room, 50 by 37 feet, used as a sleeping-room by the men employed on extra duty, and a clerks' room, 25 by 23 feet, used by the clerks of the principal office for the same purpose.

Within the triangle formed by the two wings, and east of the administration building, is the *tank*, resting upon a platform 25 feet high, and holding 12,000 gallons of water. It is supplied from a well under the engine-room, and the water forced into it by the engine which drives the machinery of the laundry. This tank supplies each ward with water by means of pipes. There are four other wells in the inclosure, used for drinking and culinary purposes.

Twenty yards east of the tank is the *laundry*, 61 by 24 feet. The building runs east and west, is two stories high, and has a platform for drying clothes on the roof. Seven men and twelve women are employed in its various departments. The washing is done by steam-power, as is also the drying and ironing. The average wash is 5,000 pieces daily—has been pushed to 7,000. On the first floor of the laundry is the washing apparatus, consisting of a mangle, steam-boiler, revolving drum for wringing, rinsing-boxes, roller and ironing table; on the second floor is the steam drying-room, 36 by 12½ feet. This is in addition to the drying arrangements on the roof. Separated by a partition from the laundry, on the first floor, is a sleeping-room for women, 22 by 24 feet; a kitchen for the same, 9½ by 17; a dining-room, 9½ by 18. The engine is in a building adjoining the laundry on the east; it is of six horse-power, and employs an engineer and an assistant. It supplies power for the tank as well as for the laundry. The well which supplies the tank is 40 feet deep, with usually 4 feet of water; its diameter is 6 feet. The steam pump can raise 2,000 gallons of water per hour.

The building for *sisters' quarters* is 23 by 51 feet, with a wing 16 by 28, forming a letter L. It is divided into chapel, sitting-room, kitchen, &c. Twenty-eight Sisters of Charity were on duty, and I must bear evidence to their efficiency and superiority as nurses. The extra-diet kitchen is under the care of a sister, and one is detailed by the superior for each ward. They administer medicine, diet, and stimulants, are under the orders of the ward surgeon, and are responsible to him alone. They have been beloved and respected by the men.

The *stewards' quarters* are 18 feet north of the engine-room, are two stories high—contain dining-room, kitchen, sleeping-room, &c. Five stewards generally occupied this building.

The *operating-room* is 25 feet east of the engine-room. It is 17 feet square, and lighted by a skylight on the north side of the roof. A revolving-table is in the center of the room; also a cupboard for instruments, sponges, microscope, &c., with a sink in the northwest corner. The examining-room adjoining it is 17 feet 7 inches square, and communicates by a door with the operating-room.

The *extra-diet kitchen* is under the same roof with the general kitchen. It is 18 by 24 feet—has in it a Harrison's European range, 8 feet front, 3 feet 6 inches deep A room 18 by 12 feet adjoins on the south. This kitchen is under the supervision of a sister, who is generally assisted by from four to six men.

The *main kitchen* is 77 by 24 feet. It contains a cooking-range, 28 feet 10 inches long and 3 feet 2 inches wide; also three of "Peters's and Johnson's bake-ovens, or roasters," two boilers for tea and coffee, each with a capacity of 120 gallons, five boilers or caldrons for soup or hash (60 gallons each), and two for heating water (one 60 gallons, the other 22 gallons). Full diet is prepared here for all the men in the hospital.

On either side of the kitchen, opening from it north and south, are the *dining-rooms*, each 146 by 24 feet, with three tables running the whole length of each, capable of seating in all 860 men. At the distal end of each room a door opens on a corridor and raised walk, so that the patients are protected from the weather in coming to their

meals. Cars, with cans fitted in them, are run around the corridors to the several wards with the food for those unable to come to the dining-room.

On the northwest corner of the kitchen is a room 30 feet long, 14 feet wide, and 10 feet high, used for washing dishes, roasting coffee, &c. From 40 to 50 men are usually employed in the various departments of the kitchen.

Opposite the center of the northern dining-room and distant to the west 30 feet, is the *fire-engine and hose-house*, 26 by 20 feet—contains one fire-engine, three hose-carriages, carrying 1,850 feet of hose, 34 ladders, 22 hooks, 278 axes, and 300 buckets.

Thirteen feet south of the kitchen is the *meat-shop*, 14½ by 23. In its center is an ice-box, 3½ by 14½, and 4 feet deep, lined with zinc. The allowance of ice per day is one pound for each man.

East of the kitchen, and connected by a covered way, is the *commissary building*, which is two stories high; the upper story is used to lodge attendants; the lower story, used for commissary store-room, is 82 by 23½, and is under a commissary steward. In the northeastern corner is the liquor-room, 8½ by 13, heavily planked and secured against marauders. All liquor is issued here on the orders of the ward surgeons. The vegetable-room is in the northwestern corner, and is 9 by 13½. An office 9 by 15½, adjoins the liquor-room. The books and accounts are kept in this office. The store-room is provided with a counter 52½ feet long, and gives employment to one steward, one clerk, and two men. At the southern end is the bread-room, 14½ by 23, which employs two men cutting bread for the tables. Adjoining, on the east, is the bakery, 14 by 23½. The oven is 10 by 16 feet.

The *chapel* is situated 63 feet east of the commissary building. It is a structure shaped like the letter T, one story in height, with a cupola on top. The main building is 24 by 78 feet. The northern end is used during the week as a reading-room. The left wing, 18 by 26 feet, is used as a library; it contains 3,000 volumes, contributed to the hospital from various sources. The right wing is the same size, and is used as a school for the freedmen employed in the hospital, who are instructed by two female teachers.

Twenty-four feet south of the chapel is the *sutler's store*, 24 by 68. The *stables*, 25 by 101, are 72 feet east of the sutler's shop; they contain 18 horses, 3 wagons, 3 ambulances, 3 carts, and 1 night-cart. Thirteen men are employed as hostlers drivers, &c. One hundred and twenty-one feet northeast of the stables is the *guard-house*, 15 by 47, and one story high. South of this are the *oil-room* and *freedmen's quarters*, 29 by 69 feet. The oil and lamp room is in the northern part. Kerosene oil was used in lighting the whole hospital, and all the lamps were filled and trimmed in this room. A corporal and two men were employed. Ninety-one feet southeast of the oil room is the *dead-house*, 15 by 40 feet. It is divided into two rooms—the northern one used in making post-mortem examinations, and the southern for plaster-casts, &c. Thirty-two feet south of this room is the *photographic gallery*, 16 by 24 feet. An operator is employed at $100 per month, paid from the slush fund. Surgical cases, pathological specimens, &c., are taken; also likenesses of all men discharged on surgeon's certificate of disability, as a guard against fraud. On the base line of the triangle are the *medical officers' quarters*, 63 by 24 and two stories in height; also, in the same line, the quarters for the *Veteran Reserve Corps*, a building two stories high, with an outside entrance stairway to the second floor. Ninety feet further back, 100 hospital tents are pitched, placed four end to end, on substantial frames, with floors raised from the ground and a door at each end of the frame. The sides of these tents were always easily raised, and gave the best of ventilation; hence I selected some of them as gangrene-wards, and, I think, with the very best results. In winter each ward was heated by two stoves, with pipes running to a shaft in the center. Each ward of four tents contained 20 beds. The length of the fence around the hospital is 1,458 yards. The distance of the fence from the tents at the base of the triangle is 124 feet. Sinks were arranged around the whole line of fence. They had movable boxes, which were regularly emptied and limed. Policing

was done by a gang of about 20 freedmen. The hospital could accommodate 1,240 patients in the 20 barrack wards. Its total capacity in January, 1865, was 2,575 beds, including those in tents and the branch barracks, a short distanee off.

This hospital was opened December 23, 1862, and closed August 22, 1865. During this period the movements of patients were as follows:

	Admitted.			Returned from furlough and desertion.	Aggregate.	Results.						
	Sick.	Wounded.	Total.			Returned to duty and mustered out.	Sent to general hospital.	Furloughed.	Transferred to Veteran Reserve Corps.	Discharged.	Deserted.	Died.
White troops	12,391	7,837	20,228	3,565	23,793	7,191	9,411	4,400	392	1,053	286	1,060
Colored troops	13	5	18	.....	18	.....	18	.....	.....	.....	.....	.....
Prisoners of war	174	959	1,133	.....	1,133	.....	924	.....	.....	45	3	161
Total	12,578	8,801	21,379	3,565	24,944	7,191	10,353	4,400	392	1,098	289	1,221

Deducting those sent to general hospital as cases not terminated, and considering that furloughed and deserted amounted to 4,686, while only 3,565 of these are reported as returned from furlough and desertion, we shall have the following statistics for the *terminated cases of white troops* treated:

Total to be accounted for excluding those sent to other hospitals, 10,817; of whom 6,339 were returned to duty, 852 mustered out of service at the close of the war, 1,121 lost by desertion and failure to return from furlough, 1,053 discharged for disability, 392 transferred to Veteran Reserve Corps, and 1,060 died.

No. 3.—Model of the Hicks Hospital, Baltimore, Md.

This is a block model on the scale of 30 feet to the inch. The following description of the hospital is taken from circular No. 6, Surgeon-General's office, November 1, 1865:

The Hicks Hospital is situated on the continuation of Townsend street, in the western suburbs of Baltimore, near the city boundary. It was opened for the reception of patients June 9, 1865, and is therefore one of the most recently constructed hospitals. The plan was essentially the circular one, but many important improvements and additions were devised by Surgeon Thomas Sim, United States Volunteers, under whose supervision the details of the plan were prepared. The original design contemplated a circular hospital, built on the War Department plan, with thirty-six radiating pavilion wards, each to accommodate sixty patients. The approach of the end of the war, however, prevented this from being executed, and the hospital, as completed, is a semicircle, in which the wards radiate from a covered way. It is, however, both on account of the substantial character of the wooden buildings and the numerous conveniences which have been carefully supplied, one of the most complete of the hospitals built during the war. (See Fig. 9.)

The wards are built and ventilated as directed in the circular from the War Department. The administration building is 132 by 38 feet and two stories high; the first story contains offices for the surgeon in charge, executive officer, quartermaster, commissary, and their clerks; it also contains the hospital library and printing office. On the second floor are sleeping apartments for officers. This building is flanked on each end by a smaller one, 70 by 28 feet, one of which contains the linen-room and

post-office, with the officers' dining-room, kitchen, and pantry. The other contains the dispensary, medical store-rooms, room of the discharge board, and an operating-room lighted by a skylight. The dining-room building is 187 by 48 feet, and is two stories high. The dining-room, which is on the first floor, is capable of seating about 1,200 patients. The second floor, which is accessible by stairs on the outside, is occupied by the chapel and by dormitories for female nurses. At the end of the dining-room is a T-shaped building for kitchen and laundry. The general kitchen, extra-

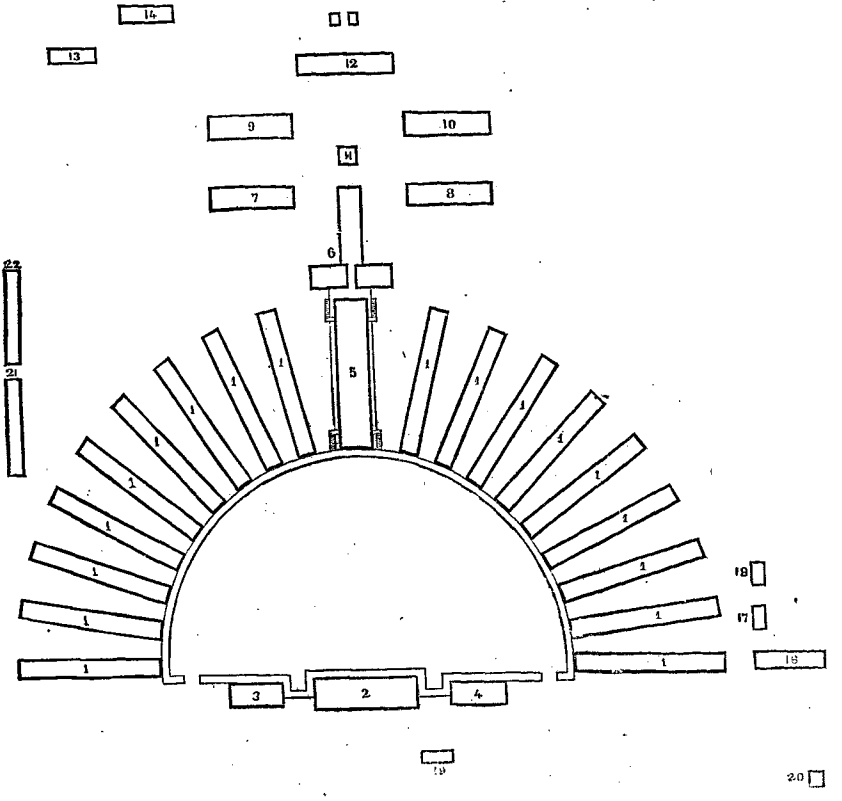


FIG. 9.—Ground plan of Hicks's General Hospital, Baltimore, Md. 1 1 1 1, Wards. 2, Administration building. 3, Linen-room, etc. 4, Dispensary and operating-room. 5, Dining-hall. 6, Kitchen and laundry. 7, Ward for detailed men. 8. Knapsack-room. 9, Commissary store-house. 10, Quartermaster's store-house. 11, Tank. 12, Quarters for guard. 13, Stable. 14, Wagon-house. 15, Sutler. 16, Steward's quarters. 17 18, Officers' houses (of which, also, there are several not in the figure). 19, Guard-room. 20, Guard-house, near entrance gate. 21, Work-shop. 22, Contagion ward; this is farther distant than is represented in the figure. The wards, dining-room, and administration building are connected by a covered way, which is indicated by faint lines in the plan.

diet kitchen, and bakery occupy separate apartments; the former two each contains a suitable range and steam fixtures, the latter two bake-ovens. The laundry has a separate room for drying by steam, and immediately adjoins the engine-room, which is at the extremity of the building. There are, besides the foregoing, separate buildings for knapsack-room, quartermaster's store-house, commissary store house, quarters for detailed men, barracks for guard, workshop, contagion ward, dead-house, stewards' quarters, and quarters for married officers. The buildings are plastered inside, are lighted by gas, to be warmed in the winter by stoves, and receive their water supply by pipes from the city water-works, besides which there is a tank for the purpose of keeping a stock of water constantly on hand in case of fire. For the purpose of extinguishing fire, there is abundant hose to fit the steam-pump. There are also

water-buckets, axes, &c. At the distal end of each ward is a lavatory and bath-room and a water-closet. Each bath-room has in it a small stove, on which is a boiler for the supply of hot water. In the water-closets the excretions are received in troughs, into which a stream of water runs, and which are emptied by withdrawing a plug several times daily. They discharge into sewers constructed for the purpose, which carry off all offensive matters entirely away from the hospital.

This hospital was opened for patients June 9, 1865, and closed March 31, 1866. The total number of white soldiers received up to this date was 1,275, of whom 1,011 were sick and 264 wounded. Of these, 404 were transferred to other general hospitals. The number of terminated cases, therefore, was 871, who are thus accounted for:

Total to be accounted for, excluding those transferred to other hospitals, 871; of whom 184 were returned to duty, 447 mustered out of service at the close of the war, 69 lost by desertion and failure to return from furlough, 119 discharged for disability, 2 transferred to Veteran Reserve Corps, and 50 died.

Besides the above, 290 colored soldiers were admitted, of whom 19 died.

No. 4.—MODEL OF THE MCCLELLAN HOSPITAL, PHILADELPHIA, PA.

This is a block-model, on a scale of 30 feet to the inch. It was constructed, as was the model of the Mower Hospital, described below, by Mr. John McArthur, of Philadelphia, the architect by whom the plans for the construction of these hospitals were prepared. The following description is condensed from an inspection report by Medical Inspector John L. Le Conte, U. S. A.:

The McClellan Hospital is located on a portion of the old Logan estate, named Stenton, situated on the Germantown turnpike, within 4 miles of Philadelphia.

The ground upon which the hospital stands is a plateau, which slopes gently and regularly to Wingahocking Creek.

This small creek has a succession of little falls and ripples, which, within the distance of half a mile, makes a descent of 25 feet or more. This creek provides one of the great requirements of a hospital—admirable drainage.

The hospital buildings were turned over to the Government on February 9, 1863. They are constructed entirely of wood, boarded outside and inside, the joints on the outside being battened. (See Fig. 10.)

The plan of the hospital is as follows: Eighteen *wards* radiate from a corridor 15 feet wide, arranged in the form of a parallelogram, with rounded extremities. In this corridor rails are placed, on which food-cars carry meals from the general kitchen to the doors of the wards. The wards are each 175 feet long, 20 feet wide, and 13 feet high to the eaves, with a pitch of 5 feet from the apex of the roof. Each ward contains 61 beds; 60 in the ward proper, and 1 in the ward-master's room. Five beds out of the 61 are intended to be occupied by the nurses and attendants, thus leaving 56 beds for patients in each ward. It may be stated, however, that most of the nurse duty, &c., is performed by convalescents, who are really patients in the hospital. The greatest capacity of the hospital proper is 1,098 beds. The present capacity of the hospital, however, is much greater, 200 beds having been placed in the corridors and 800 in hospital tents pitched in the hospital grounds, thus making the total number of beds upwards of 2,000. Each ward has a *dining-room* and *pantry* at its inner extremity next the corridor, and a *ward-master's room, lavatory, water-closet,* and *bath-room* at its outer extremity.

In addition to these, small galleries have been put up in the outer extremities of the wards, covering the entries, &c., for the purpose of stowing away articles that might otherwise encumber the wards. In the ward-master's room are closets for placing the ward clothing, and in the extremity of the entry dividing the above little offices large closed boxes have been constructed for receiving soiled clothing. Dress-

ing closets, boxes, and cupboards have been added from time to time to facilitate the working of the wards and provide every convenience for the inmates. Each ward i in fact a complete hospital within itself, except kitchen and dispensary.

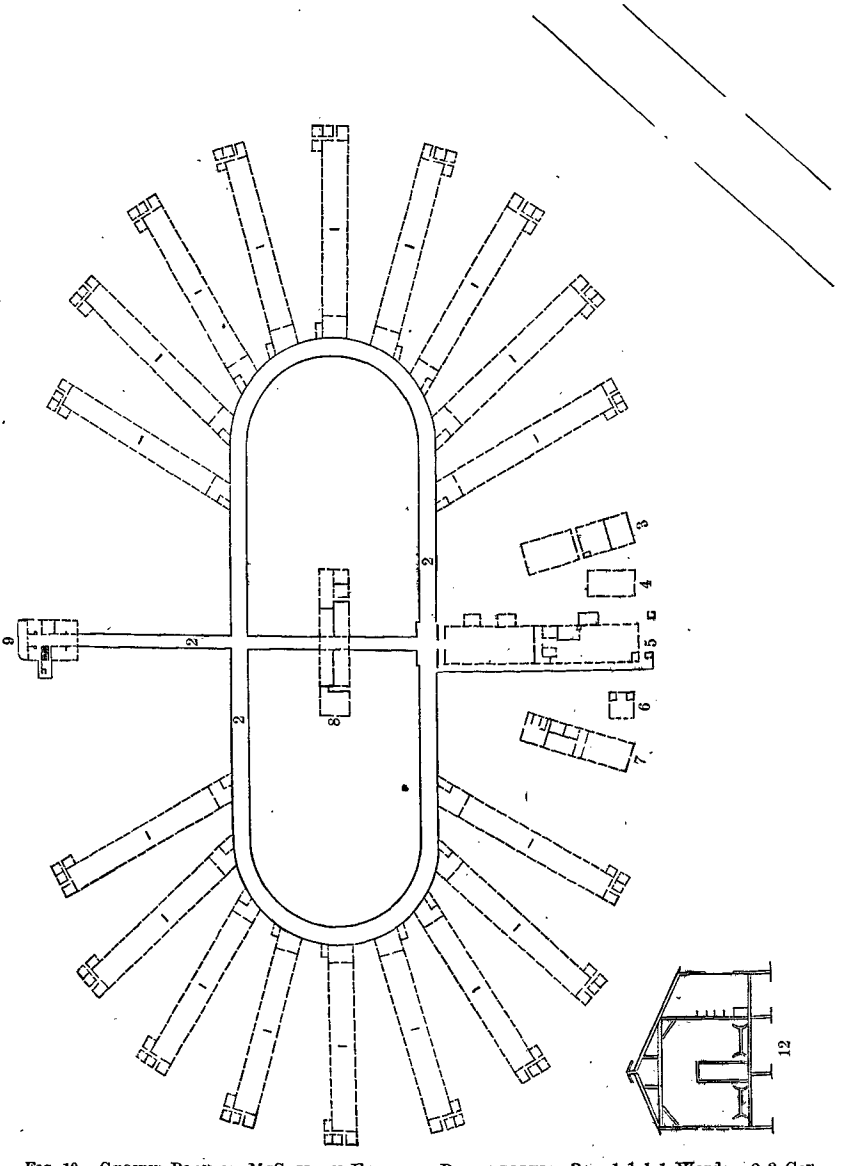


FIG. 10.—GROUND PLAN OF MCCLELLAN HOSPITAL, PHILADELPHIA, PA. 1, 1, 1, 1, Wards. 2, 2, Corridors. 3, Quartermaster's building. 4, Engine-house. 5, Kitchen building. 6, Stable. 7, Commissary building. 8, Administration building. 9, Officers' quarters. 10, Cess-pool. 11, Germantown avenue. 12, Section through end of ward.

The *commissary building* is situated on the western front of the hospital. It is 111 feet long, 24 feet wide, and 25 feet high. It contains in the lower story two store-rooms, an ice-house and meat-room, cellar for keeping ale, porter, and milk, offices

for the commissary steward, mess-room for the hospital stewards, and paint-shop. On the second floor it contains two knapsack-rooms, an office, bath-room, and dormitory.

The *quartermaster's building* is situated on the western front of the hospital. It is 111 feet long, 24 feet wide, and 25 feet high, and contains two store-rooms well provided with shelving, an office, dormitory, and green-room on the first floor; on the second floor a store-room, guard barracks, and prison room.

The *engine-house* is one story high, and is situated on the western front of the hospital, between the quartermaster's building and laundry. It is 40 feet long, 19 feet wide, and 17 feet high. There is a small additional building attached to it, used as coal-bins, with a capacity of 20 tons. Fourteen feet of the main building is partitioned off for engineers' quarters, leaving the boiler-room 26 by 19 feet. There is a bench with vise attached and all the necessary tools for making repairs. There are two tubular boilers, locomotive pattern, 10 feet long, with thirty-eight 2-inch tubes. The draught is through underground flues leading to the smoke-stack; the stack is 45 feet high. The boilers are 10 horse-power each, and supply the steam for bathing, cooking, and washing purposes, and for running two steam-pumps, one of 5 horse-power, used in case of fire; the other a 10 horse-power pump, for supplying the building with water from the wells.

The *kitchen building* is situated at the middle of the western front of the hospital. It is 172 feet long, 30 feet wide, and 28½ feet high, and is composed of two stories. The *laundry* is situated at its western extremity. The cooking-room is 90 feet long; a small store-room is attached to it, and it is well provided with sinks, hot and cold water, cupboards, closets, &c. The arrangements are ample and convenient for the original capacity of the hospital, but the tent-wards have special cooking arrangements. The cooking in the general kitchen is done by means of two large ranges, two cooking-stoves, and two double-jacketed steam-boilers.

The laundry is 74 feet long. It is well furnished, and the washing accommodations are ample, there being twenty-four stationary wash-tubs, each having two faucets, one for cold water, the other for the steam with which it is heated. There are two large steam-boilers for boiling clothes and making soap. The laundry contains also an office for the chief matron, a drying-room, an ironing-room, and the room for dirty clothing; above the laundry, in the second story, is the linen-room. The whole laundry is divided from the kitchen by a 6-foot entry. Five thousand pieces of clothing per week have been washed in the laundry, with an average of twenty-five washing women.

It may be added, however, that a considerable amount of clothing has now to be issued to laundries outside of the hospital. Over the kitchen and laundry are dormitories for the employés of those departments.

The *stable* is also situated at the western front of the hospital, between the laundry and commissary building. It is convenient and comfortable, having stalls for four horses, carriage-house, and mow above capable of holding 10,000 pounds of straw.

The *printing office* and *paint shop* are on the first floor of the commissary building; the former is furnished with a small press, with chase 9 by 11 inches. It is well supplied with type and all printing appliances. All the printing of the hospital is done here. The paint shop is a small room next the printing office. It is well supplied with painting materials.

A small building has been constructed north of the commissary building, to be used as a *carpenter's shop*. All the necessary repairs for the hospital are prepared here.

The *officers' quarters* are situated at the eastern front of the hospital, and are well located, convenient, and pleasant. The building is two stories in height, with seven chambers, kitchen, bath-room, and water-closet on the first floor, and seven chambers, bath-room, and water-closet on the second.

The *dormitories for cooks and matrons* are situated over the kitchen and laundry. The guard are quartered in hospital tents.

The *administration building* is situated in the middle of the center oval, and is connected with the main corridor and officers' quarters by a tranverse corridor running at right angles to the long diameter of the oval. In it are situated most of the offices of the hospital, viz, the offices of the surgeon in charge, executive officer, assistant executive officer, military assistant, general office for clerks, reception-room for officer of the day, officers' mess-room, dispensary, and store-room. The offices are all small; but being centrally situated, are very convenient to all parts of the hospital.

The dispensary is well arranged and ample.

The *knapsack-room* is on the second floor of the commissary building. It is provided with boxes for every bed, and is conveniently arranged. Each ward has metal checks, with the number of the ward and number of the bed stamped upon them. When patients are received these checks are placed upon their baggage, and it is then stored away in the appropriate boxes.

The *water* of the hospital is supplied by the Germantown water-works. The water bills are all estimated on the basis of 30 gallons per diem for each inmate of the hospital. Wells are now being dug, which it is supposed will supply all the water needed. Two of the wells are already constructed, and about 8,000 gallons per day are pumped from them. The water from the wells is of very good quality.

The water is distributed through the hospital by means of galvanized-iron pipes, and in case of accident or fire two main reserve tanks, with a capacity of 30,000 gallons, are kept filled to supply deficiencies.

Over the northern and southern portions of the corridor are placed two large tanks, with a capacity of 3,800 gallons each, the water in which is heated by steam; these supply the hot water for bathing, pantry, and other purposes.

A similar tank of the same size, heated by steam, is placed over the kitchen, to supply it with hot water.

The *drainage* of the hospital is arranged as follows: One line of 12-inch tile pipe surrounds the whole of the hospital buildings, just outside of the line of the fence with 4-inch pipes leading into the same from the lavatories, bath-rooms, and water-closets of each ward. Another line of 12-inch pipe surrounds the inner oval at the margin of the corridor, with 4-inch pipes leading into it from the kitchen sinks, laundry, wash-tubs, and water-closets. Both 12-inch mains connect on the southeastern portion of the hospital, and empty into a cess-pool about 150 yards in the rear. The cess-pool is 20 feet in diameter. The overflow from it is led by means of a drainage tile into the Wingahocking Creek. The solid materials are cleaned out from time to time as the pool becomes filled.

Ventilation, heating, &c.—Each building is furnished with ridge ventilation, and in the wards there are also floor ventilators between the windows, capable of being closed by sliding frames. The openings are flush with the floor and 8 inches square; there are twenty-seven to each ward. The openings in the ridge are covered by falling shutters, which are elevated and lowered by pulleys.

The hospital is heated by 256 stoves; these are watched at night during the cold season by an organized fire-guard, the same guard doing duty in the wards and corridors as watchers during the warm weather.

The hospital is lighted by gas from the Germantown gas-works.

The *water-closets* are 9 feet 5 inches long by 6 feet wide. The apparatus consists of a cast-iron sink 9 feet long and 12 inches wide, covered by a board pierced with five holes; a faucet supplies the water, and a trap removes it whenever it becomes necessary.

Each ward has also a cast-iron drip or sink for washing dishes and other work.

The *apparatus for subduing fire* consists of 2,000 feet of 2½-inch india-rubber hose, with couplings complete, eight fire-plugs, and one 5-horse-power force-pump.

Two large reserve tanks, holding 30,000 gallons of water, are placed over the main corridor, on brick walls, for the purpose of furnishing an extra amount of water should the supply from the main be insufficient.

In addition to the above, each ward has a 20-foot section of inch hose, with couplings and branch pipe, that can be attached in a moment to a small plug in the water-closet. Each ward has also in the dining-room a fire-ax, and three fire-buckets kept constantly filled. It has been stated before that an organized fire-guard patrols the hospital at night.

This hospital was opened March 12, 1863, and closed July 30, 1865. During this period the movements of patients were as follows:

	Admitted.					Results.								
	Sick.	Wounded.	Total.	Returned from furlough and desertion.	Aggregate.	Returned to duty.	Mustered out.	Sent to other general hospitals.	Furloughed.	Transferred to Veteran Reserve Corps.	Discharged.	Deserted.	Died of disease.	Died of wounds.
White troops	3,382	4,151	7,533	3,119	10,652	3,395	720	1,738	3,192	111	698	691	71	36
Colored troops	34	4	38		38	35	....	1	.....	.....	2	....	....	....
Prisoners of war	.....	25	25		25	8	....	9	.....	.....	....	....	....	8
Total	3,416	4,180	7,596	3,119	10,715	3,438	720	1,748	3,192	111	700	691	71	44

Deducting those sent to other hospitals as cases not terminated, and considering that the furloughed and deserted amounted to 3,883, while only 3,119 of these are reported as having returned, we shall have the following statistics for the *terminated cases of white troops* treated:

Total to be accounted for, excluding those sent to other hospitals, 5,795; of whom 3,395 were returned to duty, 720 were mustered out of service at the close of the war, 764 lost by failure to return from furlough and desertion, 698 discharged for disability, 111 transferred to the Veteran Reserve Corps, and 107 died.

5.—Model of the Mower Hospital, Philadelphia, Pa.

This is a block-model on the scale of 30 feet to the inch. The following description is condensed from an inspection report by Medical Inspector John L. Le Conte, U. S. A.:

The Mower Hospital is situated on an elevated plateau in the village of Chestnut Hill, about 9 miles north of the city of Philadelphia. It is on the eastern side of the railroad, and trains from Philadelphia pass every two hours. The total capacity of the hospital is 3,600 beds.

It is constructed of wood in the best manner, lined with smooth planks on the inside, and lathed and plastered on the outside. It consists of fifty *pavilions*, radiating from a corridor of a rectangular form, with rounded angles. The corridor is 16 feet wide and 2,400 feet long, inclosing a space of 7 acres. The *administration building* is located in the center of the inclosed space. This building is connected with the wards by a transverse corridor. (See Fig. 11.)

A third corridor connects the entrance to the hospital with the administration building, thus dividing the inclosure into three sections. Within the inclosure are the chapel and Bible-class room, laboratory, carpenter's shop, dining-room for attendants, boiler-room, general and extra-diet kitchen, butcher's-house, milk-house, operating-room, and dead-house, guard-house, and sutler's shop.

In the rear and on each side of the hospital are two buildings, each in the form of the letter L, and each connected with body of hospital by means of a corridor.

One-half of the one located on the northeastern extremity of hospital is used as a *barracks for convalescents*. The lower floor of the other half is occupied by the *quartermaster's* and *medical purveyor's stores*, while the upper floor is used for offices and *quarters of officers of Veteran Reserve Corps*.

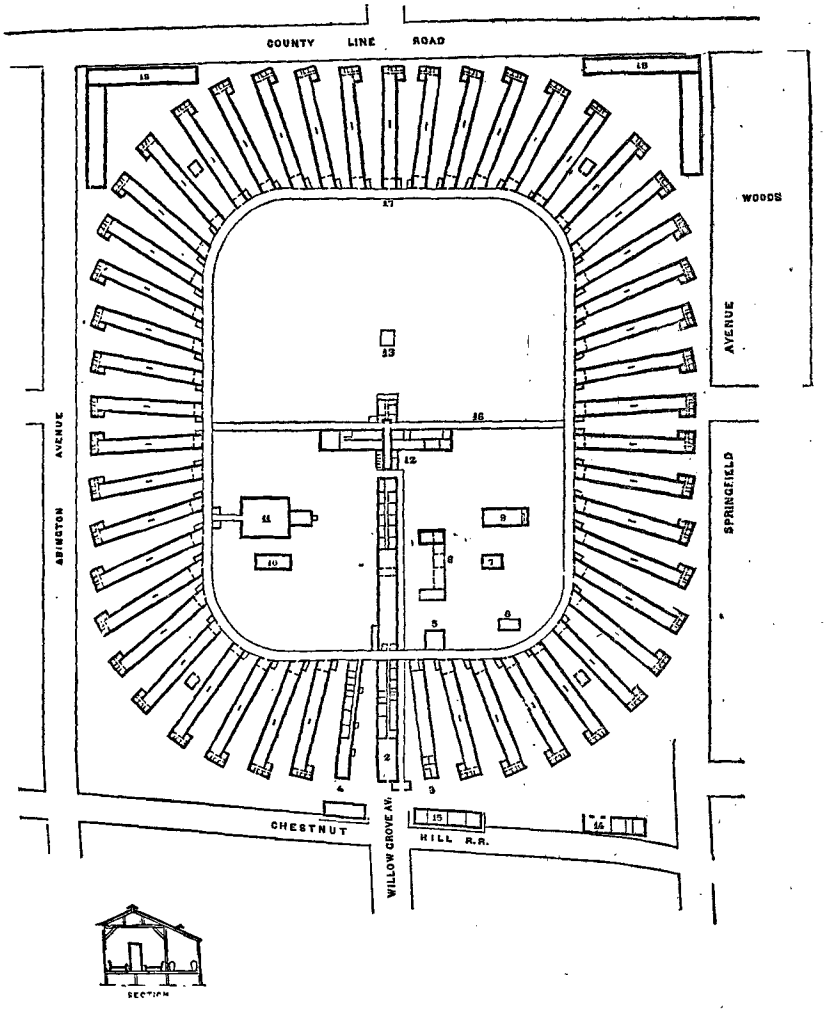


FIG. 11.—GROUND PLAN OF MOWER HOSPITAL, PHILADELPHIA, PA. 1111, Wards. 2, Reception-room, laundry, &c. In the building between this and 12 is the kitchen, &c. 3, Knapsack-room, band quarters, &c. 4, Store rooms, &c. 5, Operating room. 6, Butcher's shop. 7, Guard-house. 8, Boilers, coal, &c. 9, Sutler. 10, Carpenter's shop. 11, Chapel. 12, Administration building. 13, Ice-house. 14, 15, Railroad depots. 16, 17, Corridors. 18 18, L-shaped buildings used as barracks, store-rooms, &c.

One-half of the other L-shaped building, which is situated in the northwestern extremity of hospital, is used as *barracks for the non-commissioned officers and privates of the Veteran Reserve Corps*, the other half as a dining-room for the occupants of both barracks.

Forty-seven of the pavilions are used as *wards* for patients. Each pavilion is 175 feet long, 20 feet wide, 13 feet high to the eaves, and 19 feet to the ridge. The *dining-*

room at the entrance to each ward is 10 by 20 feet; the *scullery* adjoining, 8 by 10 feet. At the opposite end of building is a ward-master's room 10 by 12 feet, a *wash-room* 8 by 10 feet, *water-closet* 12 by 6 feet, and in an adjoining building, 10 by 12 feet, a *bath-room.*

The ward proper is 150 by 20 feet. Each ward contains 61 beds. The offices are located in the *administration building,* on the first floor. In addition to those belonging to the surgeon in charge, there is an executive office and an office for the transaction of the general business of the hospital.

Adjoining the general office is the *dispensary,* 14½ by 60 feet, with a *store-room* in the rear 29 by 30 feet. Opposite the general office is the *medical officer's mess-room* 14 by 79 feet.

The second story is divided into thirty-two rooms, used as *quarters for medical officers.*

The *operating-room* is in a separate building, 25 by 40 feet, situated to the right of the corridor connecting the entrance with the administration building. This building is divided into two rooms. The rear room is a lecture-room, containing seats for one hundred persons, where all operations are performed. This room contains closets for instruments, dressings, &c., and the medical library and pathological cabinet of the hospital. The front room, 13 by 25 feet, is used as a *dead-house,* and contains all the conveniences for post-mortem examinations, and a vault 8 feet long, 4 feet wide, and 12 feet deep, with windlass and dumb-waiter, for the reception of deceased soldiers preparatory to their burial.

Near the operating room is the *guard-house,* which is strongly built, and contains a room 20 by 15 feet, for the guards, and six small cells for prisoners; it is also provided with a water-closet. Alongside of the guard-house is the *sutler's shop,* 16 by 50 feet, connecting by a passage way with the main corridor.

The pavilion to the right of the entrance is divided into three rooms; the front and largest is used as a *knapsack-room;* the two smaller ones are used by the band. The pavilion on the left of the entrance is two stories high. On the lower floor is the reception room, mess-room for stewards, closets, &c., and the *laundry.* The second story is used as a *barracks for attendants.* The pavilion next on the left of this is used for the commissary stores, bread-room, and quarters for stewards.

On the left of corridor connecting the entrance with the administration building is the *general kitchen,* 30 by 110 feet. It contains three large-sized hotel ranges, and three London kitcheners, eight double-jacketed steam kettles for soup, and three large-sized cooking-stoves. At one end of the kitchen is the steward's room and pantry, and the other the surgeon's kitchen. In the rear of the general kitchen is the boiler-room, 29 by 29½ feet, containing two large boilers, a steam force-pump and fire-engine. On the left of the general kitchen is a *large dining-room,* 150 by 30 feet, for attendants, the *carpenter's shop,* 20 by 50 feet, and the *chapel,* 60 by 75 feet, the latter connected with main corridor by means of a passage way. The chapel is used as a *reading-room* by the patients during week-days, and contains a *library* of 2,400 books. In the rear of the chapel is a *Bible-class room,* 25 by 30 feet.

In the angle formed by the union of main corridor with corridor leading from chapel are the *post-office* and *barber shop.* To the right of the corridor connecting entrance with the administration building is the *extra-diet kitchen,* 30 by 30 feet, containing one large London kitchener complete. The *milk-house* and *butcher shop* are also on the right of the corridor.

The *supply of water* is received from the Chestnut Hill water-works into four large tanks, in the second story of the administration building, capable of holding 18,000 gallons each, and into two large tanks at the junction of the transverse with the main corridor, which hold 15,000 gallons each.

The *sewerage* consists of two large drains, one extending around the outside of the hospital, which is a brick culvert 20 by 30 inches in diameter, into which the water-closets, wash-rooms, and bath-rooms of the wards empty. The second runs outside of the corridor but within the inclosure, and is a drain of terra-cotta pipe 14 inches in

diameter, which carries off the waste water from the scullieries of the wards. Empty ing into this smaller drain are others leading from the different buildings of the hospital. Both these drains unite at the southeastern extremity of the hospital forming one large sewer, which empties its liquid contents into a creek distant from hospital half a mile. The solid contents of sewer are removed once every four months.

The hospital is *ventilated* by the "ridge" method, and by square holes through the sides of the wards flush with the floor. It is heated by coal stoves and lighted by gas.

The hospital is well supplied with all necessary *apparatus for subduing* fire. The inclosure is divided into four districts, and each district and ward is connected with the administration building by means of a telegraph. In case of fire, the alarm is struck by pulling the wire in the corridor, the bell striking the number corresponding with the number of the district in which the fire exists.

There is one hose-carriage in each fire quarter, and each district is well supplied with hose, fire-buckets, fire-axes, and ladders. A well-organized fire-brigade exists in the hospital, the members of which are drilled regularly three times a week.

The tanks inside of the corridor and outside within the inclosure are constantly kept filled with water.

This hospital was opened December 24, 1862, and closed November 14, 1865. During this period the movements of patients were as follows:

	Admitted.					Results.								
	Sick.	Wounded.	Total.	Returned from furlough and desertion.	Aggregate.	Returned to duty.	Mustered out.	Sent to other general hospitals.	Furloughed.	Transferred to Veteran Reserve Corps.	Discharged.	Deserted.	Died of disease.	Died of wounds.
White troops	11,797	10,037	21,834	4,457	26,291	10,106	1,989	4,878	4,499	865	1,937	1,695	248	74
Colored troops	22	17	39	.....	39	2	1	16	.....	....	17	.	3	....
Total	11,819	10,054	21,873	4,457	26,330	10,108	1,990	4,894	4,499	865	1,954	1,695	251	74

Deducting those sent to other general hospitals as cases not terminated, and considering that the furloughed and deserted amounted to 6,194, while only 4,457 of these are reported as having returned, we shall have the following statistics for the *terminated cases of white troops* treated:

Total to be accounted for, excluding those sent to other hospitals, 16,956; of whom 10,106 were returned to duty, 1,989 mustered out of service at the close of the war, 1,737 lost by failure to return from furlough and desertion, 1,937 discharged for disability, 865 transferred to the Veteran Reserve Corps, and 322 died.

MODELS REPRESENTING METHODS OF TRANSPORTATION.

These models represent the methods employed during the war of 1861–'65 for the transportation of sick and wounded soldiers from the field to the base hospitals (A) by water, (B) by railroad, and (C) by means of ambulances.

A.—WATER TRANSPORTATION.

Description of the models of hospital steam-vessels.

These models are intended to illustrate the plans actually employed during the war of 1861–'65 for adapting the ordinary steamboats of the

interior rivers of the United States, and the merchant steam vessels of the Atlantic coast, to the transportation of sick and wounded soldiers.

It was, of course, on the Mississippi River and its tributaries, in the rear of the great western armies, that the methods of fitting up river-boats were brought to the greatest perfection. The military operations in the Mississippi Valley, during the greater part of the war, were so related to these streams that they offered the most convenient and economical routes of transportation, and the numerous large river steamboats, which in times of peace are occupied in transporting merchandise and passengers on these waters, required comparatively little alteration to convert them into commodious hospital boats, well adapted to the transportation of the sick and wounded.

From the capacious dimensions of these boats, and their smooth motion through the waters of the broad streams on which they floated, this method of transportation undoubtedly secured greater comfort to the patients than was possible in the case of the railroads or of coast-wise transportation. Indeed, on emergencies, as after battles, these boats often served, without any special fitting up, to convey the wounded in comparative comfort to the base hospitals. But early in the war several of the most spacious and commodious of the Mississippi River passenger steamboats were specially devoted to the service of the sick and wounded, and were specially fitted up as hospital boats, or indeed it may be said as *floating hospitals;* placed under the command of a surgeon in charge, and making frequent trips between the army in the field and the base hospitals, most of which were accessible by the river or its branches. The model of the hospital steamboat D. A. January is intended to illustrate this class of vessels.

No. 6. *Model of the United States Army hospital steamboat D. A. January.*—This model was constructed under the immediate supervision of Assistant Surgeon A. H. Hoff, U. S. A., who was for a long time surgeon-in-charge. It is 5 feet long, being on the scale of one-fourth of an inch to the foot, and represents the whole vessel, with beds, &c., in position, all details being carefully worked out. The following statement with regard to this vessel was furnished by Dr. Hoff:

The hospital steamer D. A. January was built in Cincinnati, Ohio, in 1856. She was a side-wheel steamboat of 450 tons burthen, 235 feet in length, 35 feet beam, and extreme width 65 feet. She had two high-pressure engines, 22-inch cylinders, and 7 feet stroke; also a donkey-engine connecting with a steam-pump as a protection against fire.

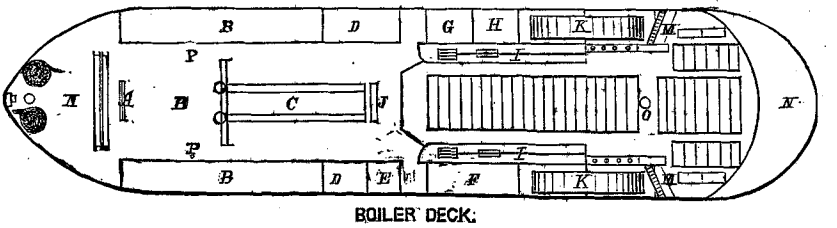
She was purchased by the Government in the spring of 1862; underwent some alterations, and made her first trip in April, 1862, arriving at Pittsburg Landing in the midst of the battle of Shiloh, loaded with a large supply of hospital stores for the purveyor at that point.

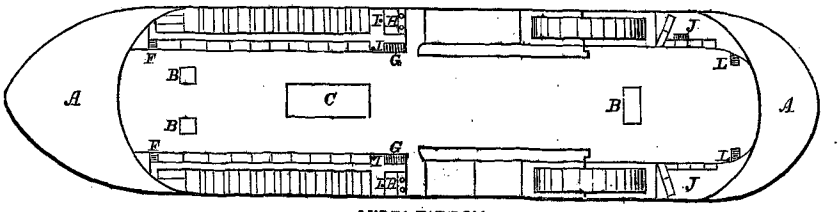
In the fall of 1862 she was completely fitted up, as shown in the model, with all the requirements of a general hospital, with a capacity of 400 beds. (See Fig. 1.)

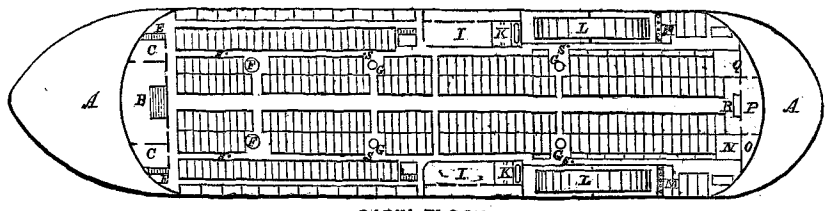
The medical officers consisted of one surgeon and three assistant surgeons, with the necessary attendants, nurses, cooks, &c.

The commanding general, by order, arranged the running of all hospital steamers

so that they could not be interfered with by the subordinate commanders, and once under way with their load of sick and wounded were not disturbed until their destination was reached. Our flag was considered a flag of truce, fully protected us, and gave us an opportunity of keeping the hospitals always in order. No persons were allowed passage on the steamers except those connected directly with the medical department of the army.







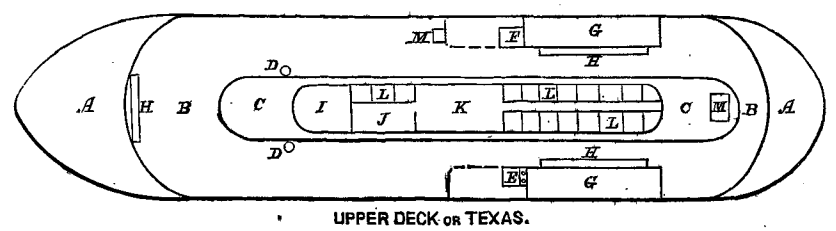


FIG. 1.—DECK PLANS OF THE HOSPITAL STEAMBOAT D. A. JANUARY. Scale, 54 feet to the inch.

Boiler deck.—A, Foot of the stairs. B B B, Space for wood and coal. C, Boilers. D D, Stores. E, Pastry-room. F, Kitchen. G, Carpenter's shop. H, Blacksmith shop. I I, Engines. J, Doctor. K K, Wheels. M M, Water-closets. N N, Deck. O, Space for beds. P P P, Ice-water stands.

Middle deck.—A A, Lower deck. B B B, Hatchways. C, Boilers. F F, Beds for patients; stairs to lower deck near the letters. G G, Stairs to upper deck. H H, Water-closets. I I I I, Ice-water stands. J J, Nurses' quarters. L L, Stairs to lower deck.

Cabin floor.—A A, Lower deck. B, Office; main stairs by the letter. C C, Private rooms. E E, Texas stairs. F F, Steamboat smoke-stacks. G G G G, Stoves. I, Nurses' dining-room. J, Kitchen. K K, Bath-rooms, with hot and cold water. L L, Steamboat wheels. M M, Water-closets. N, Private room. O, Drug-store. P, Surgery. Q, Linen-room. R, Looking-glass. S S S S, Ice-water stands. The parallelograms indicate the position of the beds.

Upper deck, or Texas.—A A, Lower deck. B B, Roof. C C, Cabin roof above the skylights. D D, Smoke-stacks. E, Water-closet. F, Wash-room. G G, Wheels. H H H, Water-tanks. I, Captain's room. J, Social hall. K, Texas dining-room. L L L, Rooms for steamboat officers. M, Private room.

To overcome the difficulty as to supplies, and the prompt payment of men employed on the boat, the "surgeon-in-charge" was made an "acting assistant quartermaster" and "commissary of subsistence," and this arrangement worked most satisfactorily, and enabled the boat to be always in readiness to leave at a moment's notice.

A large quantity of ice was carried in the hold of the vessel; this was taken advantage of by an arrangement of pipes to convey "ice water" to the different parts of the hospital. A tank was placed on the upper deck forward, connected with the steam-pump, and kept constantly filled with water; pipes from this ran down into the hold of the vessel to a coil embedded in the ice, whence the cold water made its way through pipes to the several parts of the boat where it was required. This worked admirably, giving all hands plenty of ice water, and with great economy in the use of the ice.

A fan ran through the whole length of the main ward, worked by the machinery below; it made about ninety revolutions a minute, and as the transom-windows opened just above it at the sides, it created a pleasant current of air, and had, besides, another effect, that was not taken in consideration at the time the fan was ordered, viz, that it drove out all flies and mosquitoes. The fan is seen in the model, but the water-pipes could not be shown.

Assistant Surgeon A. H. Hoff, U. S. A., then surgeon United States volunteers, was assigned to the command of this boat by order of Major-General Halleck, April 6, 1862, and continued to render efficient service as the surgeon-in-charge until February, 1864, when he was succeeded by Surgeon Lewis C. Rice, United States volunteers, who continued in charge until the boat made her last trip and was turned over to the quartermaster at Saint Louis, Mo., September 25, 1865.

During this period the boat made numerous trips from the rear of the western armies to Saint Louis, Cincinnati, Mound City, Keokuk, and other points. Moreover, during the months of March, April, May, and June, 1863, she lay near Milliken's Bend, Louisiana, and served as a floating hospital for the armies under General Grant. Altogether 23,738 patients were carried by her, of whom 530 died *en route*, as is shown by the following list of trips:

List of trips of the hospital steamer D. A. January.

Place and date of embarkation.		Place and date of landing.		Number carried.	Died on the way.
	1862.		1862.		
Pittsburg Landing, Tenn	Apr. 11	Saint Louis, Mo	Apr. 14	431	17
Do	Apr. 18	Keokuk, Iowa	Apr. 23	284	4
Do	May 2	New Albany, Ind	May 4	300	39
		Cincinnati, Ohio	May 6		
Do	May 10	Jefferson Barracks, Mo	May 14	284	7
Do	June 9	Jefferson Barracks, Mo	June 12	375	1
Do	June 19	Paducah, Ky	June 20	459	3
		Jefferson Barracks, Mo	June 22		
		Keokuk, Iowa	June 23		
Paducah, Ky	July 6	Evansville, Ind	July 7	287	2
		Louisville, Ky	July 8		
Helena, Ark	July 17	Jefferson Barracks, Mo	July 21	317	10
Paducah, Ky	July 25	do	July 27	298	------
Do	Aug. 4	Saint Louis, Mo	Aug. 5	144	------
Helena, Ark	Aug. 20	Mound City, Ill	Aug. 23	160	1
Paducah, Ky	Aug. 23	do	Aug. 23	30	------
Helena, Ark	Sept. 29	Saint Louis, Mo	Oct. 3	386	14
Do	Oct. 7	Steamer T. L. McGill, Columbus, Ky.	Oct. 10	273	6

List of trips of the hospital steamer D. A. January—Continued.

Place and date of embarkation.		Place and date of landing.		Number carried.	Died on the way.
	1882.		1882.		
Columbus, Ky	Oct. 12	Saint Louis, Mo	Oct. 15	372	.....
Do	Oct. 21	Mound City, Ill	Oct. 23	88	.....
Do	Oct. 30	Keokuk, Iowa	Nov. 4	378	1
Do	Nov. 18	Saint Louis, Mo	Nov. 21	410	2
Do	Nov. 28	Jefferson Barracks, Mo	Nov. 30	435	.....
Helena, Ark	Dec. 9	Saint Louis, Mo	Dec. 16	440	13
	1863.		1863.		
Arkansas Post, Ark	Jan. 14	Memphis, Tenn; Saint Louis, Mo	Jan. 18; Jan. 28	432	54
Served as receiving hospital at Milliken's Bend, La., during the months of—	March	Transferred to other hospital steamers, &c.	.....	1,174	46
	April		.....	1,460	79
	May		.....	736	19
	June		.....	1,195	55
Milliken's Bend, La	Aug. 11	Saint Louis, Mo	Aug. 18	378	16
Vicksburg, Miss	Aug. 27	Memphis, Tenn	Aug. 31	387	2
Do	Sept. 5	do	Sept. 8	377	9
Do	Sept. 15	do	Sept. 18	244	5
Do	Sept. 29	do	Oct. 7	78	1
New Orleans, La	Oct. 28	Cairo, Ill	Nov. 2	100	2
Memphis, Tenn	Nov. 23	Cairo, Ill; Saint Louis, Mo	Nov. 25; Nov. 27, 28	345	3
Nashville, Tenn	Dec. 9	Evansville, Ind	Dec. 12	344	.....
	1864.		1864.		
New Albany, Ind; Louisville, Ky	Feb. 11	Jefferson Barracks, Mo	Feb. 15	97	.....
Do	Mar. 18, 19	Madison, Ind	Mar. 19	463	.....
Louisville, Ky; New Albany, Ind; Jeffersonville, Ind	Apr. 7	Madison, Ind	Apr. 8	382	.....
Vicksburg, Miss	April 27	Memphis, Tenn	May 1, 2		
Memphis, Tenn	May 1	Cairo, Ill	May 3	398	1
Cairo, Ill	May 3	Louisville, Ky	May 8		
Mound City, Ill	May 3	New Albany, Ind	May 9		
Do	May 14	Jefferson Barracks, Mo	May 17	289	.....
Nashville, Tenn	May 22	New Albany, Ind	May 26	239	.....
Mound City, Ill	June 10	Jefferson Barracks, Mo	June 12	120	.....
Louisville, Ky	June 21	Evansville, Ind	June 22	498	.....
Evansville, Ind	June 22	Jefferson Barracks, Mo	June 25		
Memphis, Tenn	Aug. 10	do	Aug. 16	345	6
Do	Aug. 22	do	Aug. 27	309	1
Helena, Ark	Sept. 2	do	Sept. 9	332	5
Do	Sept. 19	do	Sept. 24	229	4
Memphis, Tenn	Sept. 20				
Duvall's Bluff, Ark	Oct. 12	Mound City, Ill; Jefferson Barracks, Mo	Oct. 19, 20; Oct. 22	407	21
Mouth of the White River, Arkansas.	Nov. 3	Cairo, Ill	Nov. 6	127	.....
Do	Nov. 10	Mound City, Ill	Nov. 14	48	.....
Nashville, Tenn	Nov. 25	Evansville, Ind	Nov. 29	361	1
Do	Dec. 1	Jefferson Barracks, Mo	Dec. 5	416	2
Louisville, Ky; Jeffersonville, Ind	Dec. 19	Covington, Ky; Cincinnati, Ohio; Camp Dennison, Ohio	Dec. 21	545	.....
Louisville, Ky; Jeffersonville, Ind	Dec. 26	Cincinnati, Ohio; Covington, Ky	Dec. 27	496	.....
	1865.		1865.		
Louisville, Ky; Jeffersonville, Ind	Jan. 5	Cairo, Ill. (for transfer to Saint Louis.); Evansville, Ind	Jan. 8; Jan. 9	426	1
Eastport, Miss	Jan 27 to Feb. 4.	Mound City, Ill	Feb. 5	373	30
Waterloo, Ala	.....	Memphis, Tenn	Feb. 8		
Eastport, Miss	Feb. 12				
Waterloo, Ala	Feb. 14	New Albany, Ind; Jeffersonville, Ind	Feb. 19	318	5
Johnsonville, Tenn	Feb. 14				
Nashville, Tenn	Feb. 16				
Chickasaw, Ala	Mar. 12-19	Jeffersonville, Ind	Mar. 23	554	8
New Orleans, La	Apr. 13	Baton Rouge, La	Apr. 14	192	.....
Do	Apr. 17, 18	Steamer Eleanor Carroll, at New Orleans, La.; Vicksburg, Miss.	Apr. 24; Apr. 25	169	.....
Selma, Ala	May 6				
Mobile, Ala	May 8	New Orleans, La	May 15	329	12
Fort Gaines, Ala	May 9	Mound City, Ill	May 25		
New Orleans, La	May 18				

List of trips of the hospital steamer D. A. January—Continued.

Place and date of embarkation.		Place and date of Landing.		Number carried.	Died on the way.
	1865.		1865.		
New Orleans, La	May 31, June 2	Vicksburg, Miss	June 5	560	
		Memphis, Tenn	June 8		
		Steamer W. Butler at Cairo, Ill., for transfer at Nashville.	June 10		
Vicksburg, Miss	June 5				
New Orleans, La	June 20	Cairo, Ill	June 28	229	7
Baton Rouge, La	June 21	Jefferson Barracks, Mo	June 29		
Vicksburg, Miss	June 23				
New Orleans, La	July 17	Cairo, Ill	July 24	328	3
Baton Rouge, La	July 18	Jefferson Barracks, Mo	July 26		
Cairo, Ill	July 24				
New Orleans, La	Aug. 3-9	Cairo, Ill	Aug. 16	439	11
Baton Rouge, La	Aug. 10	Jefferson Barracks, Mo	Aug. 18		
Vicksburg, Miss	Aug. 12				
New Orleans, La	Aug. 26	Cairo, Ill	Sept. 3	259	1
Baton Rouge, La	Aug. 27	Jefferson Barracks, Mo	Sept. 4		
Vicksburg, Miss	Aug. 28				
Total				23,738	530

Model of the United States army hospital steamship J. K. Barnes.—On the Atlantic coast a certain number of river steamboats were employed in the transportation of the sick and wounded, especially from the Army of the Potomac to Alexandria, Washington, D. C., and Baltimore. But it was also necessary to employ ocean transportation on a very considerable scale, and both in the conveyance of patients from the Army of the Potomac and from the various coast expeditions, the merchant steamships ordinarily used in the coastwise trade served for this purpose. Here, too, in times of emergency the vessels chartered by the Quartermaster's department for the transportation of stores often served to transport the sick and wounded, but a number of vessels were also devoted exclusively to this service and were fitted up as hospital steamships. The model of the United States army hospital steamship J. K. Barnes is intended to illustrate the mode of fitting up vessels of this class which was found most convenient.

This model was constructed by Mr. Charles Hemjé, of New York, under the supervision of Assistant Surgeon A. H. Hoff, U. S. A., who also directed the original fitting up of the vessel. The model is 7 feet long, being on a scale of three-eighths of an inch to the foot, and represents one lateral half of the vessel, the section being made longitudinally through the median line, thus permitting the display of the interior arrangement of bunks, &c.

The United States army hospital steamship J. K. Barnes was fitted up in New York City during the latter part of 1864, and on her completion Assistant Surgeon Thomas McMillin, U. S. A., was assigned as surgeon in charge, December 5, 1864. December 23 the Barnes was ordered to report to the medical director of the Department of the South, at Hilton Head, S. C., where she took her first load of sick on board January 1, 1865.

The Barnes was 223 feet in length, beam 35 feet 2 inches, depth of

hold 22 feet 9 inches. She was of 1,253 tons burthen. Diameter of cylinder 60 inches, stroke of piston 10 feet. In fitting her up, an orlop deck was introduced, and a mess-room was built on the forward deck, in front of the galley. The arrangement of bunks, &c., is shown in Fig. 2.

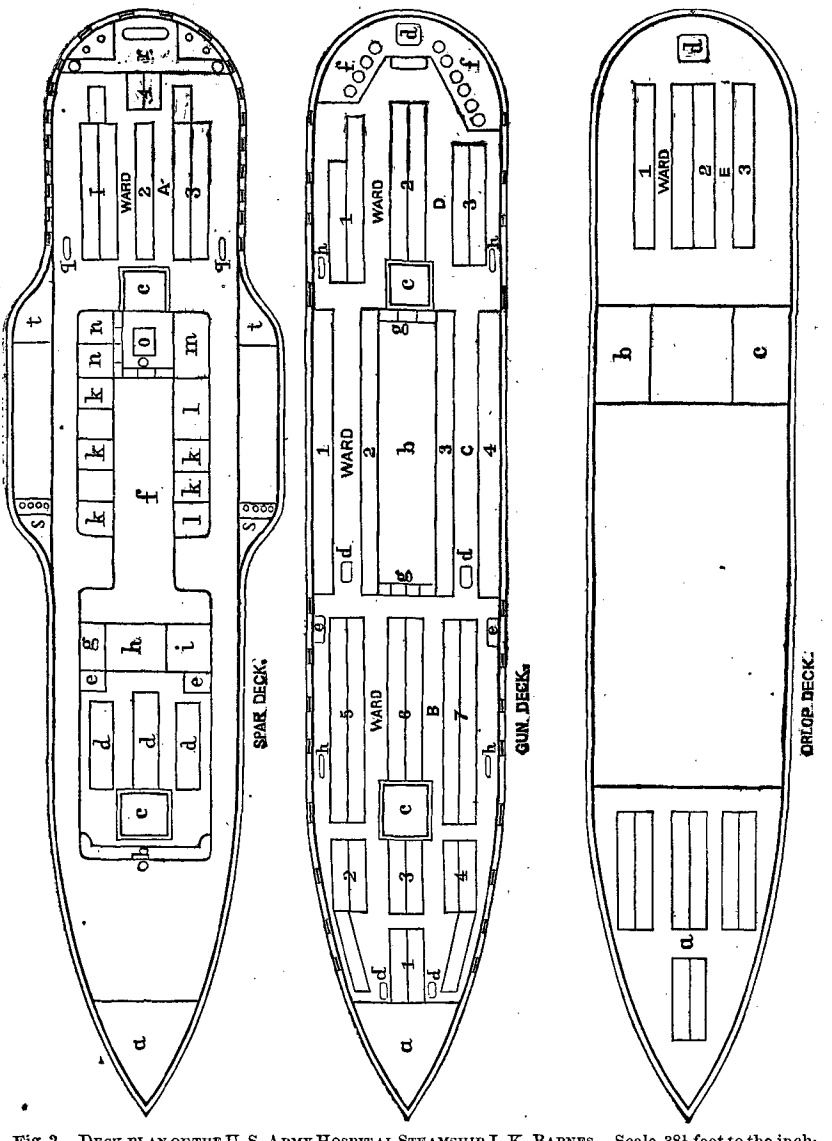


Fig. 2.—DECK-PLAN OF THE U. S. ARMY HOSPITAL STEAMSHIP J. K. BARNES.—Scale, 38½ feet to the inch.
Spar Deck.—*a*, Forecastle. *b*, Table. *c c*, Hatches. *d d d*, Mess-table and mess-room. *e e*, Pantries. *g*, Officers' mess. *h*, Galley. *i*, Ice house. *k k k k*, Quarters of medical officers. *l l*, Linen-room. *m*. Saloon. *n n*, Wine-room and office. *o*, Table. *q q*, Heaters. *r*, Bath-room and water-closet. *s s*, Water-closets. *t t*, Guard-room. Ward A, 1, 2, 3, 72 bunks.
Gun deck.—*a*, Commissary store-room. *b*, Engine. *c c*, Hatches. *d d d d d*, Ventilators. *e e*, Wash-tables. *f f*, Water-closets. *g g*, Closets. *h h h h*, Steam heaters. Ward B (forward), 1, 2, 3, 4, 5, 6, 7, 138 bunks. Ward C (midships), 1, 2, 3, 4, 42 bunks. Ward D (aft), 1, 2, 3, 63 bunks.
Orlop deck.—*a*, Quarters for nurses. *b*. Knapsack-room. *c*, Baggage-room. *d*, Ventilator. Ward E, 1, 2, 3, 48 bunks.

Assistant Surgeon Thomas McMillin, U. S. A., continued to act as surgeon in charge of this vessel until November, 1865. During this time 3,655 patients were carried, of whom 29 died *en route*. The following is a list of the trips:

List of trips of the hospital steamer J. K. Barnes.

Place and date of embarkation.		Place and date of landing.		Number carried.	Died on the way.
	1865.		1865.		
Hilton Head and Beaufort, S. C.	Jan. 1	David's Island, De Camp G. H., N. Y.	Jan. 5, 6	368	2
New Orleans, La	Jan. 31	Willett's Point, Grant G. H., N. Y.	Feb. 9	119	2
Savannah, Ga	Feb. 25	Beaufort, S. C	Feb. 26	9	.....
Beaufort, S. C	Feb. 26	Steamer Northern Light Port Royal.	Feb. 27	68	.....
Do	Mar. 14	Fort Schuyler, McDougall G. H., N. Y.	Mar. 19	320	1
Beaufort, S. C. (steamers Spaulding and Atlantic.	Mar. 15				
Wilmington and Morehead City, N. C.	Apr. 5	David's Island, De Camp G. H., N. Y.	Apr. 11	439	6
Beaufort, New Berne, and Morehead City, N. C.	Apr. 24,25	David's Island, De Camp G. H., N. Y., Willett's Point, Grant G. H., N. Y., Fort Schuyler, McDougall G. H., N. Y.	Apr. 28	449	2
Hilton Head and Beaufort, S. C.	May 7	Washington, D. C	May 11	385	.....
Savannah, Ga., Hilton Head, S. C.	May 19	Alexandria, Va	May 23	375	1
New Orleans, La	June 9	Philadelphia, Pa	June 17	217	.....
Do	July 8	New York City	July 16	25	.....
Key West, Fla	Aug. 5	David's Island, De Camp G. H., N. Y.	Aug. 23	345	5
Barracks and Fort Pickens, Fla.	Aug. 10				
Mobile, Ala.	Aug. 12				
Beaufort, S. C	Aug. 16				
Hilton Head, S. C	Aug. 17				
Charleston, S. C	Aug. 19				
Morehead City and New Berne, N. C.	Aug. 21				
New Orleans, La	Sept. 19	David's Island, De Camp G. H., N. Y.	Oct. 1	338	6
Savannah, Ga	Sept. 26				
Hilton Head, S. C.	Sept. 27				
New Orleans, La	Oct. 23	David's Island, De Camp G. H., N. Y.	Nov. 4	198	4
Pensacola, Fla	Oct. 25				
Key West, Fla	Oct. 27				
Savannah, Ga	Oct. 30				
Hilton Head, S. C.	Oct. 31				
Morehead City, N. C	Nov. 2				
		Total		3,655	29

B.—TRANSPORTATION OF THE SICK AND WOUNDED BY RAIL.

Description of the models of hospital cars.

These models are intended to represent especially those methods of adapting the ordinary rolling stock of American railroads to the transportation of sick and wounded soldiers, which were found to be most satisfactory during the war of 1861–'65. They are all on the scale of one inch to the foot, and are made of hard wood and brass, all details being carefully worked out. They are made with their roofs removable to permit the inspection of the interior. They were constructed, in accordance with plans furnished from the Surgeon-General's office, by J. G. Brill & Co., car-builders, Thirty-first and Chestnut streets, Philadelphia, Pa.

Various plans were adopted by the several armies, some of them as early as the summer of 1861, a description of which may be found in a recent report by Assistant Surgeon G. A. Otis, U. S. A.* As might have been anticipated, these methods were brought to the greatest perfection in the rear of the great Western armies, after they began to move southward from Chattanooga. While these armies were operating chiefly on the Mississippi River and its tributaries, hospital steamboats, one of which is represented by the model of the D. A. January, afforded a convenient mode of transporting their sick and wounded to the general hospitals at the base of operations and in the Northwestern States; but after they concentrated at Chattanooga this was no longer feasible, and it became necessary to extend considerably the arrangements already made by the Army of the Cumberland for the transportation of its own sick and wounded on the railroad from Chattanooga to Nashville and Louisville. The first hospital cars on this route were run between Nashville and Louisville before the concentration alluded to, but the service was subsequently extended to Chattanooga, and afterwards to Atlanta.

Surgeon George E. Cooper reports that when he became medical director of the Department of the Cumberland, in May, 1864, he found a train of hospital cars, which had been fitted up under the direction of Acting Assistant Surgeon J. B. Barnum, already in operation on the line, 185 miles in length, between Louisville and Nashville. This service he rapidly extended, (using freight cars to some extent, but giving the preference to passenger cars fitted up with litters, so as to carry the patients in the recumbent position,) until, as Dr. Otis states in the report above referred to, before the close of the year 1864—

> There were three hospital railway trains, each consisting of ten or twelve cars, with several freight or baggage cars attached sometimes, connecting the advance of the army with Nashville and Louisville; one train at least daily leaving the vicinity of the field hospitals. In each train, one car was fitted up exclusively as a kitchen and store-room, and another as a dispensary, with accommodation for the medical officer in charge, and an ample supply of medicines, stores, instruments, and appliances.
>
> These cars were fitted up under the immediate supervision of Medical Director Cooper and of Surgeon O. O. Herrick, Thirty-fourth Illinois Volunteers.
>
> General Thomas accorded the fullest authority to Medical Director Cooper to select for the hospital trains the best locomotives and cars to be found among the rolling stock, and to have new cars fitted up whenever necessary, and caused to be detailed for the hospital service the most experienced conductors, engineers, and other employés of the several railway lines. Medical Director Cooper informs the reporter that the smoke-pipes of the locomotives of the hospital trains were painted of a brilliant scarlet; the exterior of the hood, and of the tender-car with water and fuel, were of the same conspicuous color, with gilt ornamentation. At night, beneath the

*G. A. Otis, assistant surgeon United States Army. A report on a plan for transporting wounded soldiers by railway in time of war, with descriptions of various methods employed for this purpose on different occasions. Washington, War Department, Surgeon-General's office, 1875.

head-light of the engine, three red lanterns were suspended in a row. These distinguishing signals were recognized by the Confederates, and the trains were never fired upon or molested in any way. Dr. Cooper was informed by wounded Confederate officers in Nashville, who were captured at the battle near that place, of the stringent orders given his troopers by General N. B. Forrest for the non-interference with and protection of the United States Army hospital trains, by giving them timely warning in the event of the railway being obstructed or torn up. The partisan troops of Col. John Morgan's command had similar instructions. It is related that on one occasion Colonel Morgan's scouts stopped the train directed by Dr. Barnum, and having switched it off upon a siding, after inquiring if there were sufficient stores on the train for the sick and wounded, they tore up the main track, and then rifled and destroyed five supply trains that successively arrived at the point where the line was interrupted.

Ventilation, without exposure to drafts, was well provided for in these cars, by windows in the elevated part of the ceiling, and by valvular openings near the roof.

When General Sherman's army was before Atlanta, until the lines of communication were destroyed, preparatory to the march to the sea, hospital cars ran regularly from the front to base hospitals, some of which were 472 miles distant.

Assistant Surgeon F. L. Town, U. S. A., in a report on these hospital trains, states that—

The conception of a complete hospital, with all its appliances and means of comfort, propelled by steam, was first carried into practical operation in the medical department of the West, and its perfect success was most gratifying to all. In visiting these hospital trains the air is found sweet and pure, the wards neat and inviting, and it may unhesitatingly be said that men on hospital trains are often as comfortable and better fed and attended than in many permanent hospitals.

The operations of the Army of the Potomac led it for a large part of its history to occupy such camp sites that water transportation was available, and was extensively used for its sick and wounded. While this army lay along the Rapidan, however, transportation by rail became necessary, and a number of hospital cars were constructed for the purpose. Specially constructed hospital cars were also used on several of the Northern railroads, and various plans for both freight and passenger cars were employed by the Confederate authorities. An account of these devices will be found in the report of Dr. Otis, already alluded to.

No. 8. *Model hospital train.*—To illustrate this subject five models have been constructed: (*a*) represents the surgeon's car of a hospital train of the Army of the Cumberland; (*b*), the kitchen car of a hospital train of the Army of the Cumberland; (*c*), the form of car found most satisfactory for the transportation of sick and wounded in the Army of the Cumberland; (*d*), a hospital car of the Army of the Potomac; (*e*), a freight car fitted up with litters for transporting sick and wounded. These model cars are placed on a suitable track and covered with a glass case.

(*a*). *Surgeon's car, hospital train of the Army of the Cumberland.* This model represents an ordinary passenger car, with the seats removed, and with partitions and fixtures introduced, so as to lodge the

surgeon in charge of the train and his hospital steward and give accommodations for the dispensary of the train, with an office for the transaction of business.

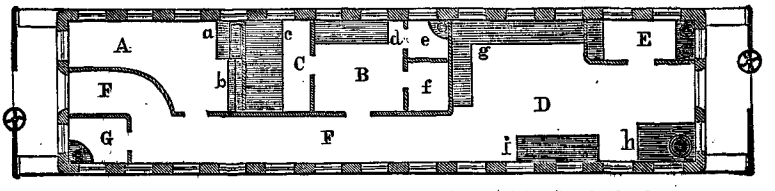


FIG. 1.—Horizontal plan of surgeon's car, Army of the Cumberland.

Fig. 1 represents the arrangements of this car.
A, dispensary and steward's quarters; *a*, desk and book-case; *b*, shelves for medicines. This apartment contains also a revolving chair at the desk and a bed for the steward.
B, surgeon's sitting-room; *d*, lounge; *e*, water-closet; *f*, clothes closet.
C, surgeon's bed-room; *c*, bed.
D, office; *g*, lounge; *h*, water-cooler; *i*, wood-box and stove.
E, wash-room, with water-basin, tank, and dressing locker.
F F, passage through car.
G, water-closet.

(*b.*) *Kitchen car, hospital train of the Army of the Cumberland.*—This model represents an ordinary passenger car with the seats removed, and with partitions and fixtures introduced for a kitchen, store-room, and dining-room.

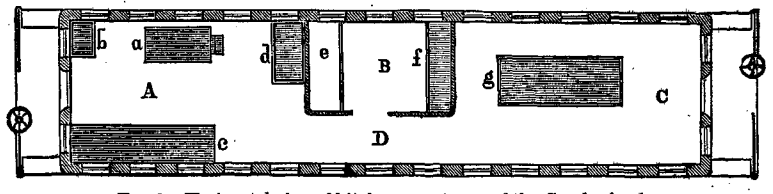


FIG. 2.—Horizontal plan of kitchen car, Army of the Cumberland.

Fig. 2 represents the arrangements.
A, kitchen; *a*, cooking-range; *b*, sink; *c*, cupboard; *d*, table and shelves.
B, store-room; *e*, ice-box; *f*, shelves for provisions.
C, dining-room; *g*, table, surrounded by benches. This apartment contains also a stove and wood-box.

(*c.*) *Car for sick and wounded, hospital train of the Army of the Cumberland.*—This model represents an ordinary passenger car, fitted up in the manner reported by Medical Director Cooper to be "the simplest and best form."

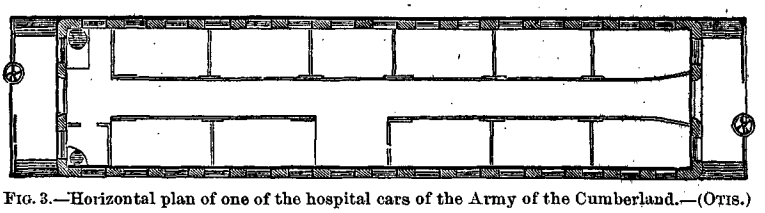


FIG. 3.—Horizontal plan of one of the hospital cars of the Army of the Cumberland.—(OTIS.)

Fig. 3 is a horizontal plan of the arrangements. Fig. 4 is a longitudinal section of a part of the car. Fig. 5, a transverse section.

The arrangements were as follows:

The alternate seats of the passenger car were removed, and suitable slats laid upon them for the reception of mattresses. On one side of

the car, one of the beds was omitted, and two windows and the adjoining paneling being removed, a wide door was introduced, "affording an ample space for the ingress and egress of litters with the most severely wounded patients." Eleven beds were thus formed, above each of which an ordinary field stretcher, with its handles shortened, was suspended by means of two iron hooks, one at each end, fixed in the side

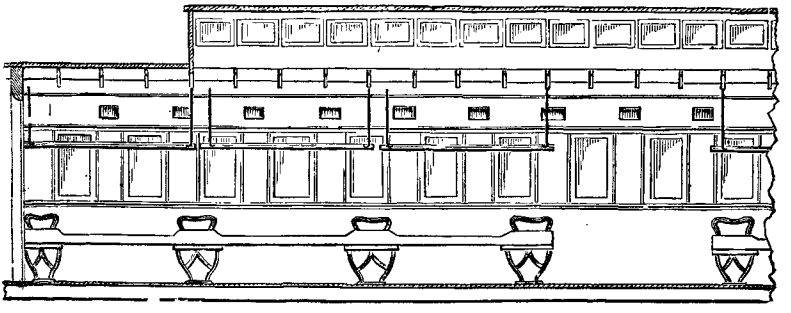


FIG. 4.—Longitudinal section of one of the hospital cars of the Army of the Cumberland.—(OTIS.)

of the car, and two iron rods terminating in hooks, which were fastened above to the roof of the car. Eleven additional beds were thus provided, so that the car would carry twenty-two patients, one to each bed, but the lower beds were so wide (about 44 inches) that two patients could be carried in each when deemed expedient (especially mild cases), in

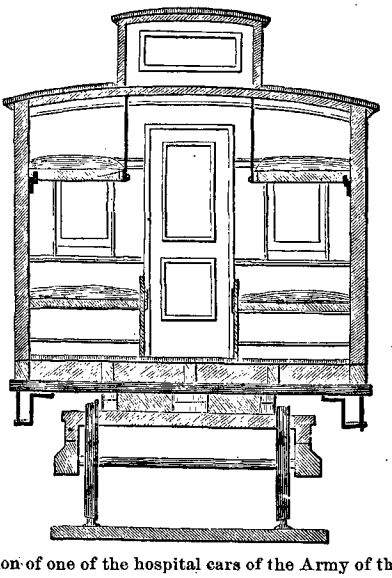


FIG. 5.—Transverse section of one of the hospital cars of the Army of the Cumberland.—(OTIS.)

which case the car carried thirty-three patients. Each car was provided with a water-closet, stove, wood-box, and water-cooler.

(*d.*) *Hospital car of the Army of the Potomac.*—This model represents the form of a hospital car devised by Mr. J. McCrickett, assistant super-

intendent of military railroads, and recommended for construction by Surgeon R. O. Abbott, U. S. A. The cars were not passenger cars re-

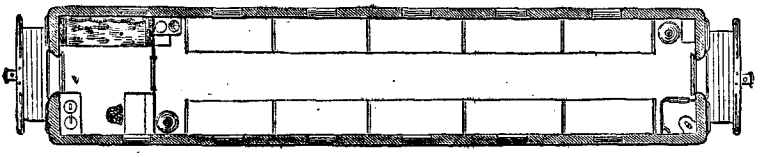


FIG. 6.—Horizontal plan of one of the hospital cars of the Army of the Potomac.—(OTIS.)

fitted, but were specially devised for the purpose, the frame-work being plain, and constructed with a special view to strength. All the details of the frame-work are faithfully worked out in the model. Fig. 6

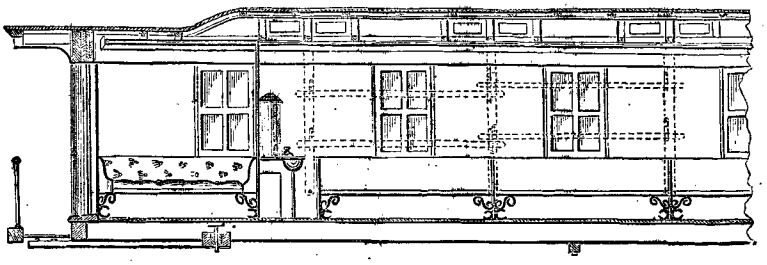


FIG. 7.—Longitudinal section of a part of one of the hospital cars of the Army of the Potomac.—(OTIS.)

is a horizontal plan. Fig. 7, a longitudinal section of a part of one of the cars. Fig. 8, a transverse section.

The cars were 45 feet long and 8½ broad, inside measure. Six and a half feet were partitioned off at one end of the car for the medical officer in charge of the car. This apartment was fitted up with a desk, shelves

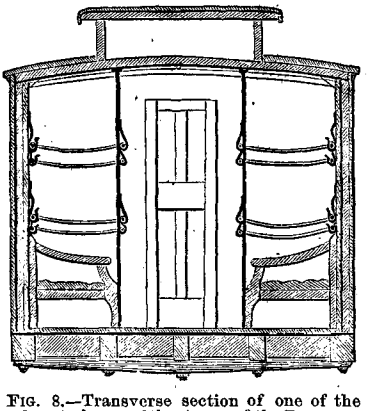


FIG. 8.—Transverse section of one of the hospital cars of the Army of the Potomac. —(OTIS.)

for books and medicines, revolving chair, and lounge. In the rest of the car ten beds were constructed, by placing seats like those used in passenger cars, but without backs, at suitable intervals. On these slats were laid for the reception of mattresses. Ten beds were thus formed,

which, however, were narrower than those of the hospital car of the Army of the Cumberland (viz, 30 inches wide), being intended for the reception of a single patient each. A passage-way 3½ feet wide was thus left. Above each of these beds two ordinary field stretchers, with their handles shortened, were suspended in the following manner: Opposite the middle of each of the seats supporting the lower beds, an upright wooden post was erected, extending from the floor to the roof and firmly fastened at each extremity. Each stretcher was supported in its place by means of two iron hooks (one at each end) fastened to the side of the car, and two leather loops (one at each end) fastened to the upright posts. Beds were thus provided for thirty patients in all. Two stoves, a water-cooler, and a water-closet completed the outfit; and in order to give ready access to the severely wounded, carried on stretchers, the door at the end of the car, intended for patients, was made 3½ feet wide.

(*e.*) *Freight car fitted up for the transportation of the sick and wounded.*—This model is intended to represent the plan devised by Grund, a German master machinist, and adjudged the most suitable for freight cars by the Prussian Commission of 1868.

It consists "in supporting three ordinary field stretchers in the front, and three in the rear part of the freight car, 20 feet long, by means of transverse wooden bars, resting on semi-elliptical plate springs. The springs are spiked at one end to the flooring, to keep the bar stationary, while at the other end are rollers to permit the yielding of the springs. The latter are surmounted by U-pieces, or clips to receive the cross-

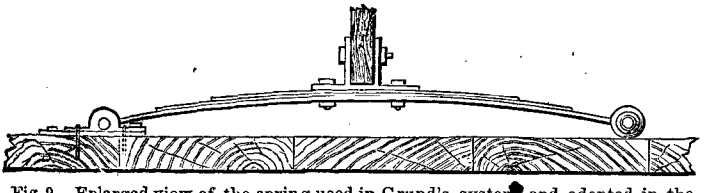


Fig. 9.—Enlarged view of the spring used in Grund's system and adopted in the Bavarian trains, for the support of litters.—(OTIS.)

bars. Four cross-beams and eight springs constitute the outfit requisite for the reception of six litters." Fig. 9 represents one of these springs, which are 3 feet in length. Fig. 10 is a longitudinal section of a part of the freight car arranged in this manner, showing a stretcher in position. The freight car represented in the model is the ordinary box car of the Pennsylvania Railroad, which is 27 feet long by 7½ broad, inside measure. By a different arrangement of the springs, eight stretchers might be accommodated, as is shown in a partial model, representing the floor of a car of the same size.

Assistant Surgeon Otis has recommended that in any future war the Quartermaster's Department of our Army should be authorized to keep on hand a supply of these semi-elliptical springs. Trains going to the front with provisions, forage, or ammunition, should then each carry, suspended under the roof, a sufficient number of these springs, with the

spikes required, to enable the car on its return, instead of going back empty, to carry comfortably, on beds improvised by means of the ordinary field stretchers, a number of sick or wounded, corresponding to its size. Assistant Surgeon Otis has also suggested that these springs might be utilized in connection with field stretchers for the comfortable conveyance of the wounded in ordinary army wagons.

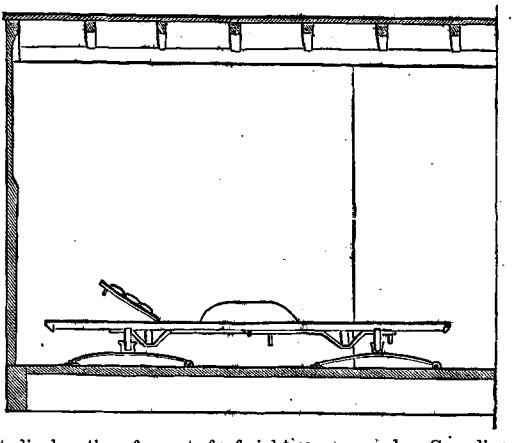


FIG. 10.—Longitudinal section of a part of a freight car arranged on Grund's system.—(OTIS.)

No. 9. *Model of wheeling ambulance*, quarter size.—This model represents the form of ambulance most extensively used and best liked during the war of 1861–'65. It is a light four-wheeled wagon intended for two horses, and fitted with two longitudinal seats, which can accommodate ten or twelve slight cases sitting, or, by raising the dependent cushions, have the seats converted into a horizontal couch on which two severely wounded men can recline. (See Circular No. 6, S. G. O., November 1, 1865, p. 84, for description and figure.)

No. 10. *Model of the Rucker ambulance*, quarter size.—This is a modification of the Wheeling ambulance, designed by General D. H. Rucker, U. S. A., of the Quartermaster's Department. It carries the same number of patients sitting, but can carry four reclining. (See Circular No. 6, p. 84, and plate facing, for description and figures.)

No. 11. *Model of the body of the McFerran ambulance*, quarter size.—This is a modification of the Rucker ambulance, especially designed by Maj. John C. McFerran, of the Quartermaster's Department, to permit the sides of the vehicle to be folded down to facilitate packing a number of the vehicles in a car for transportation to distant points.

No. 12. *Model of an experimental ambulance*, quarter size, designed by a board of officers of which General Rufus Ingalls was president, and Assistant Surgeon G. A. Otis recorder.

No. 13. *Model of the Tompkins wheel-litter*, quarter size.—This is a modification of the French wheel-litter, designed by Lieut. Col. Charles H. Tompkins, of the Quartermaster's Department.

No. 14. *Model of the larger Perot's medicine wagon.*—This model represents an ordinary army wagon on springs, with boxes and interior fixtures for medical supplies. A large number of the wagons were used during the war of 1861–'65. The chief objection to them was their weight. They required a six-mule team for convenient draft.

No. 15. *Five models of stretchers* (quarter size) of various patterns used during the war of 1861–'65.

Nos. 16 and 17. Two cases, with glass doors, containing a series of specimens intended to illustrate the medical section of the Army Medical Museum.

DESCRIPTION OF THE SELECTED SPECIMENS FROM THE MEDICAL SECTION OF THE ARMY MEDICAL MUSEUM.

The medical section of the Army Medical Museum was represented in the International Exhibition of 1876 by its printed catalogue,* (copies of which were to be found at the Hospital of the Medical Department, in rooms No. 2 and 4,) and by a small number of selected specimens exhibited in room No. 2, for the purpose of illustrating the character of the collection.

The primary object of the medical section of the Museum was to collect and preserve specimens illustrative of the diseases of soldiers, for the purpose of aiding in the study of the nature of these affections. It was desired, especially, to collect specimens of the pathological changes characteristic of those diseases which in time of war produce the chief mortality of armies, such as camp fevers and disorders of the intestinal canal. Accordingly a large proportion of the medical specimens collected during the civil war of 1861–'65 were of this character. Since the close of the war, however, a number of specimens have been received, which, although collected in military practice, represent diseases which occur also in civil life; and as the medical officers of the army on duty at garrisoned posts attend the families of the officers and enlisted men of the garrisons, a number of specimens have also been received which illustrate the diseases of women and children. Moreover, within the last few years, a number of interesting medical specimens have been presented to the Museum by physicians engaged in civil practice in various parts of the country, so that circumstances seem to favor an extension of the original design, and warrant the hope that the collection will eventually become a general pathological museum, embracing material for the study of all the various forms of disease.

A similar extension of the original plan has taken place in the surgi-

* *Catalogue of the medical section of the United States Army Medical Museum.* Prepared, under the direction of the Surgeon-General, United States Army, by Bvt. Lieut. Col. J. J. Woodward, Assistant Surgeon U. S. Army, in charge of the Medical and Microscopical Sections of the Museum. Washington: Government Printing Office, 1867.

cal section, which now embraces a large number of specimens illustrative of the most diverse injuries and surgical affections as well as of those which are especially characteristic of war; and, simultaneously, considerable collections of specimens of human and comparative anatomy and a large number of microscopical preparations have been accumulated, which are available for useful collateral study in connection with the medical and surgical collections.

Accordingly, the Army Medical Museum, which at the date of the last annual report of the Surgeon-General contained 18,109 specimens, is now divided into six sections, as follows:

IN CHARGE OF ASSISTANT SURGEON J. J. WOODWARD, U. S. A.

	Specimens.
Medical section	1,279
Microscopical section	7,275
Comparative anatomy section	1,522

IN CHARGE OF ASSISTANT SURGEON G. A. OTIS, U. S. A., CURATOR.

	Specimens.
Surgical section	6,539
Anatomical section	1,254
Miscellaneous section	240

The pathological preparations contained in the medical section are for the most part preserved in the wet way, and preference is given to dilute alcohol as the preservative medium. The chief objection to this medium is the expense of replacing the annual loss by evaporation, which, in a large collection, would amount to a considerable item if the old plan of covering the jars with bladders stretched over their mouths was adhered to. But by the plan actually adopted at the Museum, the wide-mouthed jars are closed with carefully-fitted ground stoppers. The loss by evaporation from such jars is altogether insignificant, and the difference in the first cost of the jars is but trifling. The jars used at the Museum have a glass hook depending from the under surface of the stopper, which serves for the suspension of the specimen, and the stoppers being readily removable, permit the specimens to be taken out conveniently at any time for the purpose of minute study. Intestinal preparations are usually displayed by stretching the piece upon a frame made of a glass rod bent into the desired form; and such frames, of various forms and sizes, occasionally serve for the convenient display of other specimens.

Specimens intended for the medical section of the Museum will be gladly received, not only from medical officers of the Army, but from physicians engaged in private practice in any part of the country. Such specimens, to possess value, should clearly exhibit some characteristic lesion, and should be accompanied by a carefully recorded history of the case. Examples of rare lesions are always acceptable, even when the history is imperfect; but specimens illustrative of the more common forms of disease are valued only in proportion to the care with which the history has been recorded and the degree to which the dissection

throws new light on the nature of the affection in question. Specimens of congenital malformations and of monsters are particularly acceptable, duplicates serving to make dissections for the display of internal structure. The Museum possesses at present but forty-one specimens of this class, and additional examples are much desired.

Pathological specimens intended for the Army Medical Museum should be preserved in a sufficient quantity of dilute alcohol. Ordinary proof spirit or common whisky answers the purpose very well. The quantity should be at least three times the bulk of the specimen. Large specimens, such as diseased livers, &c., have quite frequently been received at the Museum so much decomposed as to be useless, because this precaution had been neglected. Small specimens may be packed for transportation to the Museum in ordinary preserve jars; large ones in carefully-soldered tin cans or small wooden kegs. When such specimens are forwarded by private physicians the cost of transportation is always borne by the Museum, which also furnishes the jars and alcohol needed for the permanent preservation of specimens.

To avoid disappointment it is suggested that physicians who may have medical specimens which they would like preserved at the Museum, should communicate to the officer in charge of the medical section a brief memorandum of the nature of the specimen, when they will be informed whether they are desired and how they can best be sent. Specimens which have served as the basis of original communications published in the medical journals have especial interest, and it is suggested that the permanent preservation of such specimens can be better effected by presenting them to the Army Medical Museum than in any other way, and that nowhere else are they likely to be so well taken care of or so accessible for study.

The specimens from the medical section, selected for the International Exhibition of 1876, were to be found in two cases in Room No. 2 of the hospital of the Medical Department. They were for the most part specimens collected during the war of 1861–'65, and served to illustrate some of the morbid conditions incident to soldiers. The numbers in parentheses are the catalogue numbers of the specimens.

The first three specimens were tumors from within the cranial cavity. In two of the cases disturbances of the cerebral functions were observed during life, while in the third, although the tumor attained great size, it produced no symptoms which attracted attention, and the patient continued to do duty as a soldier until attacked by typhoid fever, which proved fatal.

1. (**531**.) An oval tumor (Müller's cholesteatoma) an inch and a half in diameter, which was attached to the inner surface of the frontal bone three-quarters of an inch above the right orbital plate. It was composed of flattened polygonal cells arranged concentrically in layers, between which lay great numbers of cholesterine plates. Suspended beneath the tumor in the jar is a needle-like spiculum of bone, three-quarters of an inch long, which was removed from the lesser wing of the sphenoid bone on the right side, whence it projected upwards, backwards, and outwards. From

a soldier of the Sixteenth Indiana Artillery, age twenty-one, who had long suffered from epilepsy, and who died during an epileptic fit. (*Cat. of Med. Sect.*, 1867, p. 4.) Contributed by Surgeon W. J. Woldey, U. S. Vols.

2. (**300.**) Cerebellum divided in the median line. In its anterior superior part there is an oval sarcomatous tumor the size of a walnut. It was composed of delicate spindle-shaped cells, with numerous large oval vesicles resembling atrophied nerve-cells. From a soldier of the Fifty-second Ohio, age twenty-eight, who, one month before death, was attacked with pain in the head, followed by mental disturbance and prostration. (*Cat. of Med. Sect.*, 1867, p. 4.) Contributed by Acting Assistant Surgeon H. M. Lilly.

3. (**535.**) An oval sarcomatous tumor, 3 inches long by 2½ wide, situated between the posterior lobes of the cerebrum, and attached below to the tentorium and crura cerebelli. It was composed of spindle-shaped nucleated cells, with a scanty matrix. From a soldier of the Second Massachusetts, who died of typhoid fever, with the usual intestinal lesions. So far as known, no symptoms had been produced by the tumor. (*Cat. of Med. Sect.*, 1867, p. 4.) Contributed by Assistant Surgeon R. F. Weir, U. S. A.

In the following case no brain symptoms attracted attention during life:

4. (**566.**) Portions of brain containing echinococcus cysts. From a soldier of the One hundred and thirty-fifth United States Colored, who died of chronic diarrhœa. (*Cat. of Med. Sect.*, 1867, p. 6.) Contributed by Acting Assistant Surgeon W. C. Miner.

The next three specimens are illustrations of the extension of the diphtheritic process from the throat to the air passages.

5. (**585.**) Larynx and trachea lined with diphtheritic membrane.

6. (**586.**) A portion of the lung of the same patient, showing diphtheritic casts in the branches of the bronchial tubes. From a medical officer who died of diphtheria. (*Cat. of Med. Sect.*, 1867, p. 32.) Contributed by Assistant Surgeon G. M. McGill, U. S. A.

7. (**446.**) Lower part of nose, with vomer and parts of superior maxillary bones attached; the nasal mucous membrane coated with diphtheritic membrane. The cartilaginous septum is perforated anteriorly by an old ulcer. From a soldier of the Fourth Vermont, age thirty-one, in whom diarrhœa supervened upon an amputation of the right leg for shot injury. Diphtheria set in a few days before death, and extended from the throat to the nasal mucous membrane. (*Cat. of Med. Sect.*, 1867, p. 33.) Contributed by Acting Assistant Surgeon G. W. Fay.

The next two specimens illustrate cases of laryngitis. The first terminated fatally by inflammatory closure of the glottis. The second by necrosis of the cricoid cartilage, and the formation of an abscess, which produced suffocation.

8. (**652.**) Larynx and part of trachea, showing great thickening of the epiglottis, an incision into which discovered it to be infiltrated with pus. From a soldier of the Second Arkansas Cavalry, age twenty-six, who died of acute laryngitis. (*Cat. of Med. Sect.*, 1867, p. 30.) Contributed by Surgeon William Watson, U. S. Vols.

9. (**467.**) Larynx and trachea, with enlarged bronchial glands attached. The larynx is laid open in the median line posteriorly; the incision passes through an abscess cavity, in the midst of which the necrosed cricoid cartilage lies free. From a soldier of the Fifth Pennsylvania Heavy Artillery, who, while convalescent from chronic diarrhœa, was attacked by (right) pneumonia. Numerous small subcutaneous abscesses succeeded, and fourteen days before death dyspnœa and dysphagia. He died suffocated. Miliary tubercles and intercurrent pneumonia were found in the right lung. (*Cat. of Med. Sect.*, 1867, p. 29.) Contributed by Acting Assistant Surgeon W. C. Miner.

The following case is a good illustration of empyæma:

10. (**334.**) Right lung, with a portion of the thickened pleuro costalis attached. The lung is collapsed to the size of a fist, and coated with a thin layer of lymph. From a soldier of the Fourteenth New York Militia, who died of chronic pleurisy. The right pleural sac contained about a gallon and a half of pus. (*Cat. of Med. Sect.*, 1867, p. 36.) Contributed by Acting Assistant Surgeon Joseph Leidy.

The next case is an unusual example of foreign body in the air-passages:

11. (**290.**) Lumbricoid worm lying in the larynx, trachea, and right bronchial tube. From a soldier who was choked to death by the worm finding its way into the air-passages. (*Cat. of Med. Sect.*, 1867, p. 33.) Contributed by Acting Assistant Surgeon S. B. Ward.

The next two cases are examples of cardiac disease consecutive to rheumatism.

12. (**472.**) Portion of heart, showing aortic valves ulcerated and beset with fibrinous deposits; left ventricle greatly thickened. From a soldier of the Fifth Massachusetts Battery, in whom the cardiac affection supervened upon articular rheumatism. Anasarca and great dyspnœa preceded death. The lungs were found greatly congested. There was a small quantity of fluid in the right pleural sac, and two ounces of fluid in the pericardium. (*Cat. of Med. Sect.*, 1867, p. 15.) Contributed by Acting Assistant Surgeon O. P. Sweet.

13. (**332.**) Heart and pericardium, the latter slit open to show its opposing surfaces plastered with pseudo-membranous lymph. From a soldier of the One hundred and twenty-fourth New York, who had suffered six months from rheumatism, and died of pleuro-pneumonia and pericarditis. (*Cat. of Med. Sect.*, 1867, p. 18.) Contributed by Acting Assistant Surgeon G. B. Boyd.

In the next two cases sudden death occurred: In No. 14 from the rupture of a very small aneurism in a young subject; in No. 15 the cause appears to have been the establishment of a fistulous communication between the root of the aorta and the right auricle.

14. (**558.**) Small aneurism of the aorta, just above the semilunar valves; the sac, which is about the size of a walnut, has ulcerated through into the pulmonary artery and the pericardium. From a soldier of the First Maryland Veterans, age twenty-two, who was apparently in good health, and doing guard duty, when he suddenly fell insensible, and expired in a few moments. The pericardium was found distended with blood escaped from the ruptured aneurism. (*Cat. of Med. Sect.*, 1867, p. 21.) Contributed by Assistant Surgeon A. Ansell, First Maryland Veterans.

15. (**346.**) Heart, somewhat hypertrophied, with its aortic valves partly destroyed by an ulceration, which extends deeply into the substance of the heart and communicates by a fistulous orifice with the right auricle. From a soldier of the Eighty-ninth Ohio, aged twenty-two, who died suddenly while under treatment for scrofula. (*Cat. of Med. Sect.*, 1867, p. 16.) Contributed by Assistant Surgeon C. J. Kipp, U. S. Vols.

The following case is an example of very extensive fibrinous heart-clots, formed probably during the death agony. Similar clots attracted much attention during the civil war, and were often erroneously supposed to have been the cause of death:

16. (**638.**) Heart, containing fibrinous clots in all its cavities; those in the left ventricle are long and ramifying, extending into the aorta and its branches; those in

the right ventricle extend in the same way into the pulmonary artery and its branches, but are not so long. From a soldier of the First Connecticut Cavalry, age fifty, who died of consumption, accompanied by paralysis of the lower extremities. The lungs were tubercular, and contained vomicæ; the liver and kidneys fatty; the brain was soft, and the arachnoid somewhat opaque. (*Cat. of Med. Sect.*, 1867, p. 19.) Contributed by Surgeon P. A. Jewett, U. S. Vols.

The next twenty-three specimens are illustrative of the various phases of the typhous process. No. 21 is interesting on account of the degree to which the solitary follicles of the ileum are enlarged. In Nos. 22 and 23 a somewhat similar condition in the ileum is associated with intense catarrh of the colon and luxuriant tumefaction of its solitary follicles. In the case represented by Nos. 24 and 25 the co-existence of malarial poisoning is indicated by the extreme enlargement of the spleen. Nos. 26, 27, and 28 are from cases in which the scorbutic taint complicated the fever; the patches of Peyer are converted into pultaceous sloughs. Nos. 29 and 30 are examples of intestinal perforation. Nos. 32 and 35 exhibit the cicatrices left when typhoid ulcers heal. Nos. 36 and 37 are from a case in which the typhous process co-existed with dysentery (a frequent complication).

17, 18, 19. (**376, 378, 379.**) Successive portions of ileum presenting from above downwards gradual enlargement of Peyer's patches; the thickened patches have abrupt edges, and are in many instances slightly constricted at the base like flat "sessile fungi"; and the summits of some of them are more or less ulcerated; many solitary follicles are also diseased, forming oval elevations similar in character to the thickened Peyer's patches, but smaller in size. From a soldier of the One hundred and forty-second Ohio, who died of typhoid fever. Besides the intestinal lesion, the lungs were engorged, the spleen soft, and the mesenteric glands enlarged. (*Cat. of Med. Sect.*, 1867, pp. 23 and 54.) Contributed by Assistant Surgeon W. Thomson, U. S. A.

20. (**188.**) A portion of ileum presenting thickening and ulceration of Peyer's patches and some of the solitary follicles. From a soldier who died of fever. (*Cat. of Med. Sect.*, 1867, p. 55.) Contributed by Assistant Surgeon W. A. Bradley, U. S. A.

21. (**280.**) Portion of ileum with thickened Peyer's patches; its solitary follicles enlarged to polypoid tumors the size of small shot. From a soldier who died in Lincoln Hospital of a fever diagnosed "typhus." (*Cat. of Med. Sect.*, p. 54.) Contributed by Surgeon J. H. Bryant, U. S. Vols.

22. (**817.**) A portion of ileum with Peyer's patches much thickened and ulcerated. The solitary follicles are enlarged to rounded tumors nearly the size of peas, many of them ulcerated at the apices; the villi are hypertrophied. 23. (**821.**) A portion of the descending colon, with its solitary follicles enlarged to tumors the size of peas; their apices are ulcerated. From a soldier of the Twelfth United States Infantry, age twenty-five, who died of typhoid fever. The whole colon was in the condition exhibited in the specimen. (*Cat. of Med. Sect.*, 1867, p. 65.) Contributed by Assistant Surgeon W. Thomson, U. S. A.

24. (**61.**) Portion of ileum with five thickened Peyer's patches, all ulcerated. 25. (**62.**) Enlarged spleen, 9 by 5½ by 2½ inches. From a soldier of the Thirty-second New York, age twenty-four, who died of Chickahominy fever. (*Cat. of Med. Sect.*, 1867, pp. 57 and 97.) Contributed by Acting Assistant Surgeon Joseph Leidy.

26. (**90.**) Portion of ileum with a sloughing Peyer's patch, remarkable on account of the great size and pultaceous character of its thickening. From a soldier of the One hundred and twenty-fourth New York, in whom the fever supervened upon

chronic diarrhœa. The colon was of a dirty slate color, with streaks of inflammation here and there. Pneumonia on the right side. Spleen large and flabby. A number of irregular spots of purpura, from the size of a flea-bite to that of a dime, were observed on the skin, and especially on the thighs. (*Cat. of Med. Sect.*, 1867, pp. 34, 59, and 88.) Contributed by Acting Assistant Surgeon Joseph Leidy.

27. (**181.**) Portion of ileum presenting a thickened, ulcerated Peyer's patch; the thickening, when fresh, was grumous in consistency, and of a blackish color, tinged with a livid red; its margins were indistinctly defined. From a soldier who died of what the ward physician described as "an obscure disease resembling typhus." The mesenteric glands were large and soft; the lower lobe of the right lung hepatized. (*Cat. of Med. Sect.*, 1867, p. 59.) Contributed by Surgeon T. R. Crosby, U. S. Vols.

28. (**468.**) Lower portion of ileum, with ileo-cæcal valve and part of cæcum, showing three Peyer's patches converted into pultaceous sloughs; the solitary follicles are enlarged; many of them, especially near valve, ulcerated; these ulcers presenting same character as those of Peyer's patches, but smaller. There are also a number of small sloughing ulcers on the under surface of the valve and in the cæcum. From a soldier who contracted typhoid fever before Petersburg in the fall of 1864. Petechiæ, sudamina, and hœmorrhage from the bowels were prominent symptoms. (*Cat. of Med. Sect.*, 1867, p. 60.) Contributed by Acting Assistant Surgeon W. C. Miner.

29. (**371.**) Portion of ileum with two large ulcers of Peyer's patches, one of which has perforated. There are also a number of punched-out ulcers corresponding to the solitary follicles, and a pouch-like diverticulum, the mucous membrane of which also presents a number of follicular ulcers. From a soldier of the Fifth New York Cavalry, who died of typhoid fever. Notwithstanding the extensive ulceration no diarrhœa occurred until within four days of death. There were five perforations in the ileum and evidences of general peritonitis. (*Cat. of Med. Sect*, 1867, p. 60.) Contributed by Acting Assistant Surgeon H. M. Dean.

30. (**476.**) Portion of ileum, taken several feet above the ileo-cæcal valve, with two ulcerated Peyer's patches, which present a peculiar cribriform appearance. Near the bottom of piece is a deep oval ulcer, the long diameter of which is transverse to the gut. At the bottom of this ulcer, are two oval perforations a short distance apart. The peritoneal surface of the piece is coated with a thin film of pseudo-membrane; some of the solitary follicles are ulcerated. The small intestines presented several other perforations. The patient had contracted fever before Petersburg, Va. (*Cat. of Med. Sect.*, 1867, p. 61.) Contributed by Surgeon W. L. Faxon, U. S. Vols.

31. (**510.**) A portion of the upper part of the ileum; 32, (**511,**) from near its middle; 33, (**512,**) from its lower part, including the ileo-cæcal valve. The pieces show pin-head enlargement of solitary follicles, with adherent shreds of pseudo-membrane. **511** presents a large oval cicatrix, corresponding in situation with a Peyer's patch. The ileum presented a number of such cicatrices. 34, (**513,**) is a portion of the descending colon, and shows many follicular ulcers, with a few adherent shreds of pseudo-membrane. From a patient who recovered from typhoid fever and subsequently died of chronic diarrhœa. (*Cat. of Med. Sect.*, 1867, p. 63.) Contributed by Acting Assistant Surgeon H. C. May.

35. (**489.**) Portion of ileum showing typhoid ulcers in various stages of cicatrization; the villi are hypertrophied, especially just around the cicatrices, giving a plush-like surface to the gut. From a soldier of the Seventh New York Cavalry, who died of phthisis, after recovering from typhoid fever. Tubercles were found in both lungs, and a number of large vomicæ in the left lung. There was a deposit of black pigment at the apex of each of the hypertrophied villi of the small intestine. The colon was cream-colored; its solitary follicles black with pigment. (*Cat. of Med. Sect.*, 1867, pp. 37 and 63.) Contributed by Acting Assistant Surgeon W. C. Miner.

36, 37. (**264** and **266.**) Two portions of ileum exhibiting large, deep typhoid ulcerations. 38. (**267.**) Portion of the colon, exhibiting severel large ulcers and many smaller ones. 39. (**269.**) Enlarged mesenteric glands. From a soldier of the Sixty-first Ohio, in whom typhoid fever supervened upon a previously existing dysentery. (*Cat. of Med. Sect.*, 1867, pp. 24 and 68.) Contributed by Acting Assistant Surgeon Joseph Leidy.

The next four specimens are examples of catarrhal inflammation of the small intestines, with enlargement of the solitary glands. This condition was associated, in three of the cases, with catarrhal inflammation of the colon; in case 42 the lesions of diphtheritic dysentery existed in the colon. Simple catarrhal inflammation (of both small and large intestines) was common during the war, both as an independent affection—the prominent system being diarrhœa—and as a complication of malarial fevers.

40. (**97.**) Portion of ileum, with enlargement of the solitary follicles and slight thickening of Peyer's patches. From a soldier of the Ninth Wisconsin, who died of chronic diarrhœa. The large intestine was streaked and spotted with ash color and dark red on a red ground. Lobular pneumonia existed in the lower lobes of both lungs. (*Cat. of Med. Sect.*, 1867, p. 51.) Contributed by Acting Assistant Surgeon Joseph Leidy.

41. (**84.**) Portion of ileum, showing slight thickening of Peyer's patches and enlargement of the solitary follicles. From a soldier of the Twenty-sixth Pennsylvania, age forty, who died of diarrhœa. The mucous membrane of the colon was soft, grayish, with a few streaks of inflammation and a few ecchymosed spots. (*Cat. of Med. Sect.*, 1867, p. 51.) Contributed by Acting Assistant Surgeon Joseph Leidy.

42. (**87.**) Portion of ileum, with its solitary follicles somewhat enlarged From a soldier of the One hundred and thirty-second Pennsylvania, who died with symptoms supposed to be due to typhoid fever. The mucous membrane of the colon was intensely inflamed, and everywhere covered with a thin layer of white pseudo-membrane. It presented a multitude of ecchymosed spots not larger than flea bites. The skin of the trunk and extremities presented a number of ecchymosed spots. (*Cat. of Med. Sect.*, 1867, p. 51.) Contributed by Acting Assistant Surgeon Joseph Leidy.

43. (**107.**) Portion of ileum, with solitary follicles enlarged to the size of small shot, and an apparently healthy Peyer's patch. From a soldier of the Twentieth Michigan, who died of pleuro-pneumonia, consecutive upon chronic diarrhœa. The solitary follicles of the large intestine were also enlarged, and evidences of pleuro-pneumonia existed on both sides. (*Cat. of Med. Sect.*, 1867, pp. 51 and 97.) Contributed by Acting Assistant Surgeon Joseph Leidy.

The next fourteen specimens are examples of follicular ulceration of the colon. In chronic catarrhal inflammation the enlarged solitary follicles of the small intestine long abide as little tumors like those in the foregoing specimens; but those of the colon speedily pass into ulceration, and the follicular ulceration is usually associated with inflammatory thickening of the submucosa. In such cases tenesmus is sometimes present, sometimes absent; and they are spoken of as dysentery by some surgeons, as diarrhœa by others. Pseudo-membranous inflammation of the mucous surface between the ulcers is apt to supervene in these cases, and this lesion is very generally found when acute dysenteric symptoms precede the fatal termination of a chronic flux. This

complication exists in a number of the specimens. Follicular ulcers can generally be distinguished from the ulcers of diphtheritic dysentery by their form; but in the extensive ulcerations found in some chronic cases it is sometimes difficult to be sure which process has produced the destruction of tissue observed. Nos. 53 to 56 are illustrations of this remark.

44. (**601.**) Lower portion of ileum, with ileo-cæcal valve and part of cæcum. The solitary follicles of the ileum are enlarged, the cæcum is slightly thickened and studded with minute follicular ulcers not much larger than pin-pricks. From a soldier of the One hundred and ninety-fifth Ohio, age eighteen, who died after suffering from diarrhœa for four or five weeks. Towards the close there were febrile symptoms of a typhoid character. Minute follicular ulcers, like those seen in the cæcum, were found throughout the colon. (*Cat. of Med. Sect.*, 1867, p. 63.) Contributed by Acting Assistant Surgeon W. C. Miner.

45. (**217.**) A portion of descending colon, which is considerably thickened, and presents numerous well-marked follicular ulcers. From a soldier of the Twenty-third New Jersey who died of chronic diarrhœa, contracted in the Army of the Potomac. The small intestine was inflamed in patches, and the glands of Peyer were thickened. The colon was thickened; its mucous membrane softened, and of a greenish-gray color. The ulcers were confined to the descending colon and sigmoid flexure. The lower lobe of the left lung was hepatized. (*Cat. of Med. Sect.*, 1867, p. 71.) Contributed by Assistant Surgeon E. J. Marsh, U. S. A.

46. (**438.**) Portion of transverse colon, presenting numerous follicular ulcers and slightly frosted with pseudo-membrane. From a soldier of the Sixth Ohio Cavalry, who died of chronic diarrhœa. (*Cat. of Med. Sect.*, 1867, p. 71.) Contributed by Surgeon N. R. Moseley, U. S. Vols.

47. (**121.**) Portion of transverse colon, with thickened mucous membrane and deep follicular ulcers. From a soldier of the Fourth Iowa Cavalry, who had suffered from chronic diarrhœa for nine months. The ileum presented evidences of catarrhal inflammation. The colon was throughout in the condition of the specimen. In the lower part of the colon patches of pseudo-membrane adhered to the mucous surface between the ulcers. (*Cat. of Med. Sect.*, 1867, p. 73.) Contributed by Surgeon George F. French, U. S. Vols.

48. (**56.**) Portion of ascending colon somewhat thickened, with patches of pseudo-membrane adherent to the surface and ulceration of the solitary follicles. From a soldier of the Sixty-fifth New York, who died of chronic diarrhœa. The lower part of the ileum was affected by pseudo-membranous inflammation, and the colon throughout very much as in the specimen. The lower part of the left lung was affected with pleuro pneumonia. (*Cat. of Med. Sect.*, 1867, p. 74.) Contributed by Acting Assistant Surgeon Joseph Leidy.

49. (**462.**) Portion of colon taken near the sigmoid flexure, the mucous membrane thickened, and presenting minute follicular ulcers and pseudo-membranous frosting. From a soldier of the Eighth New York Heavy Artillery, who died of chronic diarrhœa. (*Cat. of Med. Sect.*, 1867, p. 75.) Contributed by Acting Assistant Surgeon R. B. Hitz.

50. (**222.**) Portion of colon, thickened, presenting numerous pseudo-membranous patches and a few follicular ulcers. From a soldier of the Twenty-seventh New York, who died of chronic diarrhœa. The colon throughout was in the condition shown in the specimen, and the lower lobe of the left lung was hepatized. (*Cat. of Med. Sect.*, 1867, p. 76.) Contributed by Assistant Surgeon E. J. Marsh, U. S. A.

51, 52. (**223** and **224.**) Two successive portions of colon, with the mucous membrane greatly thickened and covered with a pseudo-membranous layer. In **224** there

are many follicular ulcers, which, in three or four patches, have extended into vast eroding excavations, the largest one inch and a half by one inch. From a soldier of the Thirty-seventh Massachusetts, who died of dysentery supervening on chronic diarrhœa. (*Cat. of Med. Sect.*, 1867, p. 80.) Contributed by Assistant Surgeon E. J. Marsh, U. S. A.

53. (**194.**) Portion of colon, with many follicular ulcers and a number of large, irregular, burrowing ulcers which invade the muscular coat, some penetrating even to the peritonæum. From a soldier of the One hundred and fifty-second New York, age twenty-four, who died of dysentery supervening upon chronic diarrhœa and measles. (*Cat. of Med. Sect.*, 1867, p. 77.) Contributed by Assistant Surgeon W. Thomson, U. S. A.

54. (**364.**) Portion of ascending; 55, (**365,**) of transverse, and 56, (**366,**) descending colon, near the rectum. The mucous membrane is somewhat thickened, and presents numerous excavating ulcers, many of which penetrate to the muscular, and some even to the peritoneal coat. These ulcers appear to have extended by burrowing in the submucous connective tissue; as a consequence, the latter hangs out in more or less extensive shred-like fringes, which are especially remarkable in **366.** From a soldier of the Twenty-seventh New York Battery, who died of chronic diarrhœa contracted in the Army of the Potomac. The Peyer's patches presented the shaven-beard appearance, and the neighboring solitary glands were slightly prominent. (*Cat. of Med. Sect.*, 1867, p. 78.) Contributed by Acting Assistant Surgeon D. L. Haight.

57. (**63.**) Stomach, contracted to a tube about an inch in diameter in its pyloric half, and about 2 inches in diameter at the largest part of the greater curvature. 58. (**64.**) A portion of the descending colon considerably thickened, presenting numerous follicular ulcers. From a soldier of the One hundred and fourth Pennsylvania, who died of chronic diarrhœa. (*Cat. of Med. Sect.*, 1867, pp. 46 and 72.) Contributed by Acting Assistant Surgeon Joseph Leidy.

In the last case the stomach appears to be in a state of extreme contraction from the anæmia resulting from chronic diarrhœa. In the next the colon is in a similar condition from the anæmia of hæmorrhage.

59. (**458.**) Portion of transverse colon very much contracted. From a patient who died of secondary hæmorrhage after amputation of the thigh. (*Cat. of Med. Sect.*, 1867, p. 70.) Contributed by Surgeon Thomas Sim, U. S. Vols.

The next thirteen specimens are, with one exception, illustrative of the morbid processes of diphtheritic dysentery. The characteristic lesions are pseudo-membranous deposits on the surface of the mucous membrane, involving also the mucosa and submucosa, and giving rise to sloughing, the sloughs invading the tissue of the bowel as deeply as the pseudo-membranous deposit; the resulting ulcers are usually of considerable size. In the case represented by No. 63, an interesting anomaly of the right kidney existed, which is shown in No. 64.

60. (**125.**) Portion of descending colon, with pseudo-membranous patches and a few ulcers. From a soldier of the Ninety-third Indiana, age twenty, who died of dysentery. There were a few traces of inflammation here and there through the small intestine. The cæcum was inflamed and softened. The transverse and descending colon ulcerated. In the sigmoid flexure and rectum the mucous membrane was almost entirely destroyed by ulceration. (*Cat. of Med. Sect.*, 1867, p. 75.) Contributed by Surgeon George F. French, U. S. Vols.

61. (**135.**) Portion of transverse colon, with numerous oval ulcers, which vary in size from that of a three-cent piece to that of a quarter of a dollar. From a soldier of the Ninety-fifth Ohio, age twenty-five, in whom dysentery supervened upon diarrhœa. An abscess containing 20 ounces of pus was found in the anterior superior part of the right lobe of the liver. The mucous membrane of the ileum was dark red and softened, with patches of livid green. The colon ulcerated, as in the specimen, the ulcers appearing to have resulted from the separation of diphtheritic sloughs. In the cæcum two of them had perforated, giving rise to fœcal extravasation and general peritonitis. (*Cat. of Med. Sect.*, 1867, p. 76.) Contributed by Surgeon George F. French, U. S. Vols.

62. (**289.**) Portion of colon, with its mucous membrane thickened and coated with pseudo-membrane. There are in the piece several large eroding ulcers, which have destroyed the mucous coat and expose the transverse fibers of the muscular layer. From a soldier of the One hundred and eighth New York, age twenty-four, who died of dysentery. There were patches of inflammatory congestion in the lower part of the small intestine; the colon throughout as in the specimen. (*Cat. of Med. Sect.*, 1867, p. 77.) Contributed by Assistant Surgeon W. Thomson, U. S. A.

63. (**362.**) Portion of transverse colon, with numerous superficial ulcers resembling those resulting from the separation of diphtheritic sloughs. 64. (**361.**) Right kidney converted into a cyst about the size of a small orange, the wall of which is fibrous and about four lines thick; it is connected by a patulous ureter with the urinary bladder. Two renal arteries, the size of crow-quills, proceed from the aorta at the point of its bifurcation, and ramify upon the walls of the cyst. This cyst was situated over the second lumbar vertebra. The left kidney was apparently healthy, but the patient had had albumen in his urine. From a soldier of the Forty-eighth Pennsylvania, who died of dysentery, complicated by pleurisy. The left lung was compressed against the vertebral column by a large quantity of greenish-yellow seropurulent fluid. There were a few ulcers in the ileum. The colon was ulcerated throughout. (*Cat. of Med. Sect.*, 1867, pp. 77 and 106.) Contributed by Assistant Surgeon W. F. Norris, U. S. A.

65. (**383.**) Portion of ascending colon, the mucous membrane of which is thickened, and presents numerous large excavating ulcers, occupying a large portion of its surface. Detached shreds of mucous membrane, coated with lymph, hang from the edges of the ulcers. From a soldier of the Second Battalion Veteran Reserve Corps, who died of dysentery. The colon throughout was in the condition of the specimen. (*Cat. of Med. Sect.*, 1867, p. 78.) Contributed by Assistant Surgeon H. Allen, U. S. A.

66. (**367.**) Portion of the transverse, and 67, (**368,**) of the descending colon. In both the mucous membrane is thickened and presents numerous large, irregular ulcers, such as result from the separation of diphtheritic sloughs. From a soldier of the First Maryland, age twenty-two, who died of dysentery. (*Cat. of Med. Sect.*, 1867, p. 78.) Contributed by Surgeon N. R. Moseley, U. S. Vols.

68. (**422.**) Portion of the transverse, and 69, (**423,**) of the descending colon, presenting large eroding ulcers which penetrate in **422** to the muscular coat, and several of them in **423** to the peritonæum; the mucous membrane much thickened. From a soldier of the Seventh Maine Battery, age sixteen, who died of dysentery. There was also some ulceration in the lower part of the ileum. (*Cat. of Med. Sect.*, 1867, p. 78.) Contributed by Surgeon E. Bentley, U. S. Vols.

70. (**849.**) Portion of colon, much thickened, with jagged and extensive ulcers, at the edges of which the mucous membrane hangs in shreds; some pseudo-membrane adheres to those portions of mucous membrane which are not destroyed. From a negro, age fifty, who died of dysentery in the Freedmen's Hospital, Washington. Metastatic foci were found in the right lobe of the liver, and scattered tubercles in both lungs. (*Cat. of Med. Sect.*, 1867, p. 79.) Contributed by Assistant Surgeon E. Bentley, U. S. A.

71. (**148.**) Portion of colon, the surface of which has been extensively eroded by ulceration, leaving, however, numerous little islets of intact mucous membrane, in many of which pin-head ulcers of the solitary follicles can be seen. From a soldier, of the Sixty-second New York, who died of diarrhœa (dysentery ?). (*Cat. of Med. Sect.* 1867, p. 73.) Contributed by Acting Assistant Surgeon E. Hartshorne.

72. (**1280.**) Cæcum and part of the colon, with diphtheritic sloughs. From a soldier of the Eleventh United States Infantry, who died of dysentery, at Fort Sill, Ind. T., September 13, 1874. This man was first taken sick with symptoms of acute diarrhœa, which passed into fatal dysentery. In this case the cæcum and ascending colon had become adherent to the abdominal walls in the right iliac region, and one of the ulcers in each having perforated, a fœcal abscess had formed in the abdominal walls, which communicated by one opening with the cæcum, by another with the ascending colon. Two other perforations in the colon had led to fœcal extravasation into the abdominal cavity and general peritonitis. (Specimen received since Catalogue was printed.) Contributed by Acting Assistant Surgeon C. W. Knight.

The next five specimens are from cases of scurvy. The cribriform condition of the aortic valves shown in No. 75 has been supposed to be a characteristic lesion, but this is somewhat doubtful. With these specimens should be considered Nos. 26, 27, and 28, which present the typhoid lesions as modified in scorbutic subjects.

73. (**4.**) Larynx, posterior third of tongue, half arches, and tonsils; both tonsils the seat of foul, irregular, and gangrenous ulceration. From a patient who died in Marine Hospital, New Orleans, in 1862. One of a number of fatal cases in the same hospital, in which gangrenous ulceration of the mouth and throat occurred in debilitated and anæmic (scorbutic) men. (*Cat. of Med. Sect.*, 1867, p. 45.) Contributed by Acting Assistant Surgeon R. K. Browne.

74. (**6.**) Anterior half of larynx, with posterior third of tongue attached. Situated on the right side, below the rima glottidis, is a deep phagedenic ulcer, which has dissected between the cricoid and thyroid cartilages. The perichondrium of the cricoid is destroyed, and the cartilage itself, at the bottom of the ulcer, is of bone-like hardness from calcareous deposits. From a soldier who died in the Marine Hospital, New Orleans, in 1862. One of a number of fatal cases in the same hospital, in which gangrenous ulceration of the mouth and throat occurred in debilitated and anæmic (scorbutic) men. (*Cat. of Med. Sect.*, 1867, p. 29.) Contributed by Acting Assistant Surgeon R. K. Browne.

75. (**840.**) Aortic valves, slightly cribriform at their edges. 76. (**838.**) A portion of ileum with pin-head enlargement of solitary follicles, and slight thickening of the Peyer's patches. 77. (**839.**) A portion of the greatly-thickened sigmoid-flexure, with small follicular ulcers. From a man, age twenty-nine, who died at Brownsville, Tex., of scorbutic diarrhœa, after about two months' illness. (*Cat. of Med. Sect.*, 1867, pp. 14 and 65.) Contributed by Assistant Surgeon Ira Perry, Ninth U. S. Colored.

The next three specimens are examples of metastatic foci, quite like those which occur in pyæmia after gunshot wounds, but resulting in these cases from other causes. The point of departure of the metastatic process appears to have been a subcutaneous abscess in No. 78, an ulcerated colon in No. 79, and a collection of pus in the left pleural sac in No. 80.

78. (**848.**) Upper and middle lobes of right lung, containing numerous metastatic foci. From a freedman who died of pyæmia consecutive to superficial abscess of the right hand, which did not involve either bone, periosteum, or tendons. Metastatic foci were found in both lungs and in the kidneys. (*Cat. of Med. Sect.*, 1867, p. 35.) Contributed by Assistant Surgeon E. Bentley, U. S. A.

79. (**449.**) Section of right lobe of liver, containing numerous metastatic foci, from a quarter to half an inch in diameter. From a soldier of the Second New York Heavy Artillery, who died of dysentery. Jaundice and bilious vomiting were observed before death. The colon presented extensive diphtheritic ulceration. (*Cat. of Med. Sect.*, 1867, pp. 80 and 93.) Contributed by Assistant Surgeon Wm. F. Norris, U. S. A.

80. (**325.**) Perpendicular section of spleen, which is lobulated, considerably enlarged, and irregularly infiltrated with metastatic masses. When received at the Museum the spleen was so soft as to be easily torn with the finger, of a livid blood-color in part, partly bluish-black; the metastatic foci bright yellow, and consisting entirely of granular matter, in which were embedded the partly disintegrated anatomical elements of normal splenic structure. From a soldier of the Sixth Wisconsin, in whom pain in the side, cough, and hectic followed a malarial fever. The left pleural sac contained a pint and a half of purulent fluid; the right about six ounces of serum. Peyer's patches presented the appearance of "the newly-shaved chin." The solitary glands of the ileum were enlarged, but not ulcerated. The liver was enlarged and contained a large number of metastatic foci. (*Cat. of Med. Sect.*, 1867, p. 99.) Contributed by Assistant Surgeon G. A. Mursick, U. S. Vols.

The next sixteen specimens are illustrative of tubercular deposits and scrofulous inflammation. These processes were frequently manifested in intense forms among the colored troops and freedmen. Nos. 81 to 85 are a series of specimens from a remarkable case of general tuberculosis, accompanied by scrofulous inflammation of various organs, characterized by bulky cheesy deposits. No. 86 is an illustration of bulky cheesy deposits in the pleural sac of a scrofulous freedman. Nos. 87, 89, 90, and 91 are examples of tubercular ulceration of the bowels. Nos. 88 and 92 of tubercular peritonitis. Nos. 93, 94, and 95 are examples of tubercular deposits in the spleen, and No. 96 of cheesy deposits in the left suprarenal capsule.

81. (**540.**) Portion of base of cranium, with cervical vertebræ attached. Anteriorly, the carious bodies of the vetebræ have been denuded by an abscess, which communicated through the anterior occito-atloid space with the base of the brain. Posteriorly, the spinal cord is seen *in situ*. The dura mater spinalis is surrounded externally by a cheesy mass, which is most abundant in the region of the atlas and axis. The basilar process of the occipital bone, the declivity of the sphenoid, and the sella turcica are covered with a cheesy mass, situated for the most part between the bone and the softened dura mater. 82. (**541.**) The bony bridges and spinous processes of the second, third, and fourth cervical vertebræ, with soft tubercular deposits between the external periosteum and the bone on the right side; some newly formed bone on the left. 83. (**542.**) Lower part of sternum, with costal cartilages and parts of ribs attached. A cheesy mass involves the substance of the sternum at the attachment of the fifth and sixth right costal cartilages. On the left side there is a similar mass at the junction of the fourth rib with its cartilage. 84. (**543.**) Urinary bladder with prostate and vesiculæ seminales attached, both containing cheesy deposits. The central portion of the prostatic deposit has softened into an abscess, which communicates with the urethra. 85. (**544.**) Heart, presenting a Cruveilhier's spot about an inch in diameter on the anterior surface of its right ventricle. From a colored recruit, who died after a few months' illness. Besides the extensive lesions exhibited in the specimens, cheesy deposits were found in the lymphatic glands, in the lungs, &c. (*Cat. of Med. Sect.*, 1867, pp. 16, 112, 117.) Contributed by Acting Assistant Surgeon W. C. Miner.

86. (**567.**) Section of the left side of the thorax. The lung is connected to the walls of the chest by a thick cheesy layer, which also fills the anterior mediastinum.

From a freedman, who died in L'Ouverture Hospital, Alexandria, Va. The cheesy layer coated the whole of the left lung, and invaded the lower portion and the diaphragm. The heart was pushed to the right, so that its apex was at the left edge of the sternum. The right lung was normal. The spleen contained tubercles about the size of peas. (*Cat. of Med. Sect.*, 1867, p. 40.) Contributed by Acting Assistant Surgeon W. C. Miner.

87. (**692.**) A portion of ileum, taken at the ileo-cæcal valve, with tubercular ulceration of Peyer's patches and of some of the solitary follicles. On the peritoneal surface of the piece, especially opposite the ulcers, are several small tubercles. 88. (**693.**) Portion of omentum, in which several tubercles, the size of millet-seed, are embedded. From a consumptive colored woman who died in the Freedmen's Hospital, Washington, D. C., and who suffered from diarrhœa and dropsy for some time before death. Both lungs were found tubercular, the left presenting numerous vomicæ. There were also tubercles in the liver and spleen, about a pint of serum in each pleural cavity, and four ounces in the pericardium. The abdominal cavity was distended with fluid, and presented evidences of tubercular peritonitis. The ileum presented numerous ulcers, as in the specimen, and ulcers of the solitary follicles were numerous in the cæcum and scattered throughout the colon. (*Cat. of Med. Sect.*, 1867, pp. 38, 82, and 88.)

89. (**252.**) A portion of the ileum presenting tubercular ulceration. From a soldier of the Third Vermont, age twenty-three, who died of tuberculosis and dysentery. The lungs were tubercular. The small intestine presented numerous ulcers similar to that shown in the specimen. For the most part these ulcers had their long diameter transverse to the length of the intestine, and miliary tubercles existed on the peritoneal surface opposite to them. The mucous membrane of the colon was thickened, ulcerated, and coated between the ulcers with patches of pseudo-membrane. (*Cat. of Med. Sect.*, 1867, p. 83.) Contributed by Acting Assistant Surgeon Joseph Leidy.

90. (**428.**) Piece of upper portion of the jejunum, presenting, near its middle, a large ulcer, the long diameter of which is transverse to the length of the intestinal canal. On the peritoneal surface, opposite the ulcer, are a number of small tubercles. 91. (**431.**) A portion of the cæcum, with the vermiform appendix. An irregular, ragged ulceration surrounds the orifice of the appendix, the mucous membrane of which is ulcerated throughout. The cæcum presents a number of large, irregular ulcers. From a teamster who died of consumption and diarrhœa. Both lungs were found tubercular. The larynx was ulcerated. Many ulcers, resembling those in the specimen, existed in both small and large intestines. (*Cat. of Med. Sect.*, 1867, pp. 24, 29, and 84.) Contributed by Acting Assistant Surgeon H. M. Dean.

92. (**664.**) Several knuckles of intestine, beset with numerous thread-like adhesions, and presenting on the peritoneal surfaces of intestines and mesentery a number of tubercles of different sizes. From a soldier of the Twenty-seventh United States Colored, age twenty-one, who died of phthisis. Both lungs were tubercular; the bronchial glands enlarged. The surfaces of all the abdominal viscera were in the condition exhibited in the specimen. (*Cat. of Med. Sect.*, 1867, p. 89.) Contributed by Surgeon E. Bentley, U. S. Vols.

93. (**298.**) Spleen, with a number of small tubercles just beneath its peritoneal coat. From a soldier of the One hundred and forty-fifth Pennsylvania, age twenty-nine, who died of chronic diarrhœa. There were tubercles in both lungs, and the mucous membrane of the colon was ulcerated. (*Cat. of Med. Sect.*, 1867, pp. 73 and 99.) Contributed by Surgeon E. Bently, U. S. Vols.

94. (**564.**) Spleen, laid open by a longitudinal incision, showing in its interior and on its external surface numerous tubercles. From a negro who died of phthisis, accompanied by diarrhœa. Tubercular deposits and cavities were found in the lungs, miliary tubercles in the liver, and tubercular ulcers in the intestinal canal. (*Cat. of Med. Sect.*, 1867, p. 99.) Contributed by Acting Assistant Surgeon W. C. Miner.

95. (**632.**) Spleen, weighing thirteen ounces, containing numerous tubercles the size of hazelnuts. From a soldier of the Eighth United States Colored, who died of general tuberculosis. Tubercular deposits were found also in the lungs and liver, and the peritonæum was studded with tubercles. (*Cat. of Med. Sect.*, 1867, p. 100.) Contributed by Assistant Surgeon E. D. Buckman, U. S. Vols.

96. (**841.**) Left suprarenal capsule infiltrated with cheesy masses. From a soldier of the One hundred and eighteenth Colored, age twenty who died of scorbutic diarrhœa. The lower lobe of the right lung was hepatized; the mucous membrane of the lower part of the ileum and the colon inflamed but not ulcerated, and scattered tubercles were found in the liver. (*Cat. of Med. Sect.*, 1867, p. 109.) Contributed by Assistant Surgeon Ira Perry, Ninth U. S. Colored.

The next five specimens are from a remarkable example of multiple melanotic cancer.

97. (**824.**) Lobulated melanotic tumor, weighing thirteen ounces, from the left inguinal region. 98. (**828.**) A portion of the lower lobe of the right lung, presenting a lobulated melanotic mass about the size of a hen's egg at its inferior angle. 99. (**829.**) Section of liver, presenting several melanotic nodules; the largest were three-fourths of an inch in diameter. 100. (**830.**) Portion of pancreas, presenting a number of melanotic nodules, the largest about the size of a pea. 101. (**831.**) Right kidney, the pelvis of which is occupied by a rounded melanotic nodule about an inch and a half in diameter. From a freedman, age sixty, in whom numerous other similar deposits were found. The melanotic masses were soft, and composed for the most part of irregular, more or less polygonal cells, about one-thousandth of an inch in diameter, containing large oval nuclei and brownish-black pigment granules. (*Cat. of Med. Sect.*, 1867, pp. 25, 41, 95, 97, 108, and 117.) Contributed by Assistant Surgeon E. Bentley, U. S. A.

The four remaining specimens present anomalies of the liver, spleen, and kidneys.

102. (**639.**) Perpendicular section through right lobe of liver, showing a great number of cysts and sinuous passages, the largest nearly a quarter of an inch in diameter. These are dilated gall ducts, which, in the recent specimen, contained a yellowish serum-like fluid. From a soldier of the Twenty-third United States Colored, who died of fever which began as intermittent, and assumed a typhoid character as it progressed. Some thickening of the patches of Peyer was observed at the autopsy. The gall-bladder contained a little viscid bile. (*Cat. of Med. Sect.*, 1867, p. 95.) Contributed by Surgeon E. Bentley, U. S. Vols.

103. (**534.**) Deeply lobulated spleen, with six supernumerary spleens attached; the latter vary from one inch to less than half an inch in diameter. From a soldier of the One hundred and forty-sixth New York, who died after resection of the hip, performed for gun-shot fracture of the left femur. (*Cat. of Med. Sect.*, 1867, p. 97.) Contributed by Assistant Surgeon W. F. Norris, U . S

104. (**29.**) Right kidney, laid open; larger than the left; weight twenty-four ounces; filled with cysts, the largest of which attains the size of an English walnut. From a soldier of the Second Vermont Sharpshooters, who died of chronic diarrhœa. No attention had been drawn to his kidneys during life. The left kidney was in a similar condition, though not so large; it weighed fourteen ounces. (*Cat. of Med. Sect.*, 1867, p. 107.) Contributed by Surgeon J. S. Hildreth, U. S. Vols.

105. (**536.**) Urinary organs, showing extensive alterations resulting from stricture of the urethra. The pelvis of the right kidney is greatly dilated, and its pyramids enroached upon, so that the kidney forms a multilocular cyst, the walls of which are composed of atrophied renal tissue. The pelvis of the left kidney is also greatly distended. The ureters are dilated to size of the forefinger. The muscular coat of the

bladder is hypertrophied, the thickened bundles of muscle forming an areolar arrangement, through the meshes of which a number of herniæ of the mucous membrane have taken place, forming oval cysts, the largest of which is over two inches, the smallest about a quarter of an inch in diameter. These cysts communicate with the cavity of the bladder by comparatively narrow orifices. From a soldier of the One hundred and twenty-second Ohio, age forty-three, who had a stricture of the membranous portion of the urethra, which still, however, permitted the passage of urine. He was admitted to hospital in articulo mortis, and had constant dribbling of urine, with involuntary evacuations of the fœces. (*Cat. of Med. Sect.*, 1867, p. 109.) Contributed by Assistant Surgeon R. F. Weir, U. S. A.

Nos. 18 and 19. Two cases with glass doors, containing a series of specimens to illustrate the surgical section of the Army Medical Museum.

DESCRIPTION OF THE SELECTED SPECIMENS FROM THE SURGICAL SECTION OF THE ARMY MEDICAL MUSEUM.

In the historical notes on the United States Army Medical Department, compiled by Dr. Harvey E. Brown,* may be found an account of the inception and progress of the collections that constitute the Army Medical Museum, with a copy of Circular No. 2, of May 21, 1862, in which—

As it is proposed to establish in Washington an *Army Medical Museum*, medical officers are directed diligently to collect and to forward to the office of the Surgeon-General all specimens of morbid anatomy, surgical or medical, which may be regarded as valuable; together with projectiles and foreign bodies removed, and such other matters as may prove of interest in the study of military medicine or surgery. * * * The announcement of this project was cordially responded to by medical officers throughout the service.†

The "names of many most eminent for zeal and ability in the discharge of their duties under the Government" became identified with the undertaking. It was unnecessary "to stimulate the liberality with which most valuable material was forwarded"; for, on January 10, 1863, Surgeon John H. Brinton, U. S. V., was able to present a printed catalogue,‡ prepared by Assistant Surgeon William Moss, U. S. V., with brief descriptions of "nine hundred and eighty-five surgical specimens, a hundred and six medical, and one hundred and thirty-three missiles"; but, in order to indicate the class of specimens it was especially desired to secure, and to define the proper methods of preparing and transmitting them, an additional circular letter of instructions was issued June 24, 1864.

* *The Medical Department of the United States Army from* 1775 *to* 1873. Compiled under the direction of the Surgeon-General by Harvey E. Brown, assistant surgeon U. S. Army, Washington, D. C., Surgeon-General's Office, 1873 (p. 225 *et seq.*)

† See the Prefatory chapter to the *Medical and Surgical History of the War of the Rebellion*, by Surgeon-General Joseph K. Barnes, United States Army, Washington, 1870, p. 6. The Circular Letter of June 24, 1864, subsequently referred to, is reprinted in these Prefatory observations.

‡ Moss (W.), *Catalogue of the Army Medical Museum*, Surgeon-General's Office, January 1, 1863. Octavo, pp. 58, Washington, Government Printing Office.

Soon after the conclusion of the war it was found that the collections of the Army Medical Museum had so greatly augmented that it became necessary to revise their classification. Instituted originally for the collection and preservation of specimens illustrating the injuries and diseases that produced death or disability during the war, and thus affording materials for precise methods of study of problems regarding the diminution of mortality and alleviation of suffering in armies, the Museum had received many contributions relating to collateral subjects. Many pathological specimens not immediately relating to military medicine or surgery had been donated. Many preparations of human and comparative anatomy had been received. A cabinet of microscopical preparations, in which were many illustrations of original research, had been accumulated. Models and drawings of hospitals, medical and surgical instruments and appliances in great variety, had been forwarded. Numerous objects of ethnological or archæological interest had been contributed. Therefore the Surgeon-General directed the subdivision of the collection in six sections: 1, a surgical section; 2, a medical section; 3, a microscopical section; 4, a section of human anatomy; 5, a section of comparative anatomy; 6, a miscellaneous section. In 1866 quarto printed catalogues were published of the surgical,* medical,† and microscopical sections.‡ An act making appropriations for a descriptive catalogue of the anatomical section, in folio, with plates of the principal types of North American crania, has long been pending before Congress. A preliminary catalogue of the section of comparative anatomy has recently been printed.§ The catalogue of the sixth, or miscellaneous section, is preserved only in manuscript; for, although there are some objects permanently classified in this subdivision, such as samples or models of hospital and sanitary appliances, instruments, weapons, and the like, a large number of contributions, such as minerals, fossils, stone implements, Indian curiosities, &c., are but temporarily deposited, awaiting exchange with other museums or

* *Catalogue of the Surgical Section of the United States Army Medical Museum.* Prepared under the direction of the Surgeon-General U. S. Army by Alfred A. Woodhull, Assistant Surgeon and Brevet Major, U. S. Army, Washington, Government Printing Office, 1866. Much of the preliminary work on this catalogue was done by Drs. J. H. Brinton, F. Schafhirt, Moss, Billings, B. Stone, Spencer, C. C. Lee, and Otis, and all the illustrations were made under the direction of the last named.

† *Catalogue of the Medical Section of the United States Army Medical Museum.* Prepared under the direction of the Surgeon-General U. S. Army, by Brevet Lieutenant-Colonel J. J. Woodward, Assistant Surgeon U. S. Army, in charge of the Medical and Microscopical Sections of the Museum, Washington, Government Printing Office, 1867.

‡ *Catalogue of the Microscopical Section of the United States Army Medical Museum.* Prepared under the direction of the Surgeon-General U. S. Army, by Brevet Major Edward Curtis, Washington, Government Printing Office, 1867.

§ *List of the Skeletons and Crania in the Section of Comparative Anatomy* of the United States Army Medical Museum, for use during the International Exhibition of 1876, in connection with the representation of the Medical Department U. S. Army, Army Medical Museum, Washington, D. C., 1876.

collections, in return for objects more nearly related to the purposes of the Army Medical Museum.

The surgical section, at the close of the war, presented a very complete series of specimens of the immediate and remote effects of lesions of the various tissues by war weapons, and of the results of operations necessitated by such injuries. Moreover, the instruments and appliances included in the materia chirurgica were fully represented by samples or by models; and the field hospital service and transport of wounded by land and water was well illustrated. The catalogue of this section printed in 1866 comprised forty-seven hundred and nine specimens. The dissection, preparation, and mounting of the specimens had been faithfully and skillfully executed by the veteran prosector, Dr. F. Schafhirt, who had been engaged in this work from July 1, 1862. It was regretted that with such affluence of examples of the results of injuries, especially of shot injuries, illustrations of surgical diseases were comparatively few in number, and earnest efforts were made to supply this deficiency, and to have general and special surgical pathology fairly represented in this section. Partly by purchases, partly by exchanges, partly through the generous contributions of surgeons in civil life, and largely by the zealous co-operation of the officers of the medical staff, a satisfactory advance has been made in this direction. An interesting pathological cabinet, collected chiefly by the labors of Professors Miller, Stone, and Lincoln, of the National Medical College, were obtained in exchange for a series of pictures and models suitable for class demonstration, that had been prepared when a project for the establishment of an Army Medical School had been contemplated. The cabinet of the late Dr. William Gibson, of the University of Pennsylvania, comprising over eight hundred specimens, was purchased. Donations of tumors, of diseased bones and joints, of herniæ, of aneurisms, and of vesical calculi, in large number, were received from Drs. Sterling, Bontecou, Eve, Forwood, Mastin, May, Wright, McGuire, and many others. From the Soldiers' Home, at Washington, and the several asylums for disabled volunteer soldiers, some remarkable illustrations of surgical diseases or of the remote effects of injuries were received. The labors of the medical men of the corps, who have rarely neglected to preserve any morbid parts that may be removed, or failed to make necroscopic examinations in fatal cases, provided many valuable contributions.

At the present time, the section contains sixty-six hundred and four specimens, and the annual increase for the last five years has been very gratifying, both in the number and quality of the contributions. As the extent and nature of the collection has become more generally known to the profession, the circle of contributors has steadily enlarged. The facilities offered by the Museum for the permanent preservation of pathological materials and permanent record of explanatory clinical observations are now widely appreciated. Busy practitioners, who cannot spare time for minute dissections or preparations of morbid growths or diseased

tissues, willingly forward to the Museum what they remove by operation or find in their autopsies, with the assurance that the pathological material will be carefully analyzed, and, if of value, prepared and preserved, with a record of the clinical facts communicated. It is only necessary to pack the material suitably for transportation by express, boxed in sawdust and salt, or using hermetically sealed cans, with alcohol, when necessary; the freight charges are defrayed by the Museum, and the specimens accepted are mounted in the best manner, and all data respecting them are placed on record, and are subsequently referred to in the printed catalogues, available for reference by medical men in every land. Moreover, in cases of especial interest, the Museum will return to its contributors photographic prints of their specimens after preparation.

A series of specimens from the section has been selected for exhibition at the Centennial Exhibition at Philadelphia, with the hope that they may not only prove interesting and instructive to pathologists, but may aid in diffusing among practitioners a knowledge of the objects the Army Museum has in view.

1.—Illustrations of Injuries of the Cranium.

1. (**3639.**) A calvaria showing the effects of contusion by a shot projectile an inch behind the coronal suture. There is superficial necrosis without, and slight fissure and depression within. The patient survived the injury seventeen days. (See *Cat.* 1866, p. 8; *Med. and Surg. Hist.*, Part I, Vol. II, p. 146.) Donor, Dr. H. Mullen.

2. (**1568.**) Section of left parietal with fracture of the inner table, from oblique impact of a musket-ball on the outer table. Patient died of meningitis after nine days. (See *Circ.* 6, S. G. O., 1865, p. 10; *Cat.* 1866, p. 7; *Med. and Surg. Hist.*, Part I, Vol. II, p. 142.) Contributed by Dr. R. W. Coale.

3. (**4194.**) A very remarkable exfoliation from the right parietal after shot contusion with depressed fracture of the *tabula vitrea*. The patient recovered, and was pensioned. In 1870, the loss of substance in the skull was reported to be partly replaced by bone, partly by fibro-ligamentous tissue. (See *Cat.* 1866, p. 11; *Med. and Surg. Hist.*, Part I, Vol. II, p. 149.) Donor, Dr. H. M. Bellows.

4. (**2121.**) Segment of right parietal; one fragment of a conical ball, which split longitudinally upon the bone, was extracted from within the cranial cavity; the other fragment lodged beneath the occipito-frontalis. The patient survived the injury thirteen days. (See *Cat.* 1866, p. 14, and *Med. and Surg. Hist.*, Part I, Vol. II, p. 181.) Donor, Surgeon J. Dwinelle, One hundred and sixth Pennsylvania.

5. (**3220.**) Segment of the calvaria of a quadroon of twenty-one, showing a perforation of the left parietal by a pistol ball at close range. The missile was arrested on the opposite side, after traversing both hemispheres of the cerebrum. The patient survived five days. (See *Cat.* 1866, p. 25, and *Med. and Surg. Hist.*, Part I, Vol. II, p. 318.) Donor, Surgeon E. Bentley, U. S. V.

6. (**1108.**) Part of cranium, showing a conoidal ball embedded and incrusted between the sphenoid and frontal bones. The aperture of entrance through the right orbit is partly obliterated by osseous depositions. The patient lived sixty-four days after the injury. No marked cerebral disturbance appeared until the ninth week. (See *Cat.* 1866, p. 28; *Med. and Surg. Hist.*, Part I, Vol. II, p. 205.) Donor, Dr. G. H. Dare.

7. (**5116.**) Base of a cranium, with a round pistol-ball embedded in the left carotid canal. The specimen was purchased with the Gibson cabinet. It was found in the catacombs of Paris; and, according to tradition, the patient survived the injury many years.

8. (**849.**) Skull showing fissures of all the cranial bones, resulting from a musket-ball perforation. (See *Cat.* 1866, p. 30.) Donor, Surgeon J. B. Green, U. S. V.

9. (**5922.**) Skull of a man of thirty-two years. Fractures resulting from a rifle-musket ball discharged close to the head have implicated all of the cranial bones. Donor, Assistant Surgeon C. Carvallo, U. S. A.

10. (**4344.**) Segment of the frontal, trephined three weeks after injury on account of intracranial suppuration, following shot contusion with a depressed fracture of the inner table. The operation afforded no relief, and the patient succumbed the following day. (See *Cat.* 1866, p. 6; *Med. and Surg. Hist.*, Part I, Vol. II, p. 148.) Donor, Dr. R. B. Bontecou.

11. (**5024.**) Section from os frontis of a man of thirty-three years. He received a depressed fracture from a blow by a stone in 1842, when twelve years of age. Epilepsy supervened, and he was trephined in 1845 by Dr. Nathan R. Smith. The epilepsy was not alleviated. He became idiotic, and died in 1863. A tough diaphanous membrane, composed of horny epithelium, covers the orifice made by the trephine. Donor, Dr. Joseph Borrows. (See *Med. and Surg. Hist.*, Part I, Vol. II, p. 319.)

12. (**6600.**) Calvaria showing a punctured fracture. The perforation, made by the hammer of a pistol, was not detected during life. Death from cerebritis after three days. Donor, Assistant Surgeon C. K. Winnie, U. S. A.

13. (**5908.**) Cranium of a soldier of the Fourth Cavalry, killed by Indians near Fort Concho, Tex., September 30, 1870. The iron arrow-head impacted in the left temporal with but slight splintering, produced speedily fatal intracranial hemorrhage. (See *Circular* No. 3, S. G. O., 1871, p. 150.) Donor, Bvt. Maj. W. M. Notson, Assistant Surgeon U. S. A.

14. (**5531.**) Cranium of a California Indian, killed by a stone-headed arrow, which is seen penetrating the left malar bone and orbit. The skull was found by Dr. C. Yates, in Alameda County, California, and was contributed to the Smithsonian Institution, and numbered 8106. It was transferred to the Army Medical Museum January 25, 1867.

15. (**2179.**) Skull-cap exhibiting a bayonet perforation behind the left parietal protuberance from a soldier who received the injury November 27, and died December 23, 1863, after suffering from cerebral hernia and extended suppuration of the left hemisphere. (See *Circular* No. 6, S. G. O., 1865; *Cat.* 1866, p. 34; *Med. and Surg. Hist.*, Part I, Vol. II, p. 32.) Donor, Dr. C. J. Kipp.

16. (**3307.**) Calvaria of a negro boy of eighteen years, with four saber cuts of the left parietal, and depressed fractures of both parietals. (See *Med. and Surg. Hist.*, Part I, Vol. II, p. 19.) Donor, Surgeon H. Wardner, U. S. V.

17. (**5107.**) Cranium showing a saber cut of the right parietal. The skull, supposed to have been cleft by one of the long straight swords of the French cuirassiers, was brought from Waterloo in 1813. Purchased with the Gibson collection.

18. (**970.**) Skull of an Araucanian Indian killed by Chilian troops. There are nine cleanly-cut sword wounds on the bones of the head and face. Received in exchange from the Smithsonian Institution.

19. (**2619.**) Segment of the os frontis, showing the repair of a depressed fracture. The date of the injury was unknown. The patient died of typhoid fever July 2, 1865. (See *Cat.* 1866, p. 10; *Med. and Surg. Hist.*, Part I, Vol. II, pp. 165, 319.) Donor, Assistant Surgeon D. C. Peters, U. S. A.

20. (**2964.**) A wet preparation of a segment of the os frontis, showing the effects of necrosis remotely following shot contusion. (See *Cat.* 1866, p. 10; *Med. and Surg. Hist.*, Part I, Vol. II, p. 105.)

II.—ILLUSTRATIONS OF INJURIES OF THE TRUNK.

1. (**2843.**) Six dorsal vertebræ, showing a shot fracture of the spinous and transverse processes and lamina of the third vertebra. The ball passed through the left lung, and the patient survived only one day. (*Cat.* 1866, p. 58; *Med. and Surg. Hist.*, Part I, Vol. II, p. 435.) Donor, H. M. Dean.

2. (**2762.**) Third lumbar vertebra, with a conoidal ball and shreds of clothing embedded. The patient died from tetanus after nine days. (*Cat.* 1866, p. 60.) Donor, Dr. G. A. Mursick.

3. (**5553.**) Spinous process of a lumbar vertebra, with a flint arrow-head incrusted in it. Discovered in some human remains exhumed by Dr. A. I. Comfort from a tumulus near Fort Wadsworth, Dak. (See *Circular* No. 3, S. G. O., 1871, p. 163, and Dr. Comfort's paper in the *Annual Report of the Smithsonian Institution* for 1871, Washington, 1873, p. 389.)

4. (**5673.**) Three vertebræ from a white citizen murdered by Indians near Fort Concho in 1867. An arrow-head is impacted in the right transverse process of the fourth dorsal vertebra. Other arrows penetrated the thorax and abdomen. (See *Circular* No. 3, S. G. O., 1871, p. 153.) Donor, Bvt. Maj. W. M. Notson, U. S. A.

5. (**6528.**) Sternum and portions of adjacent ribs and cartilages lacerated by a musket-ball, which opened the mediastinum and exposed the heart to view during life. The patient survived seventeen days. (*Med. and Surg. Hist.* [second issue], Part I, Vol. II, p. 535.) Donor, Dr. H. Ludington.

6. (**2902.**) Fifth lumbar vertebra and sacrum, with a musket-ball impacted in the upper left sacral foramen. From a soldier, twenty-three years old, wounded May 10, 1864, became paraplegic, and died May 15, 1864. (See *Cat.* 1866, p. 227; *Med and Surg. Hist.*, Part II, Vol. II, p. 248.) Donor, Dr. O. P. Sweet.

7, 8, 9. (**4869,'70,71.**) Sternum, heart, and knife. The sternum and heart exhibit incisions through the gladiolus and right auricle, made by the knife. The specimens are from a case of assassination at Fort Dodge, Kans., June 2, 1867. (See *Med. and Surg. Hist.*, Part I, Vol. II, p. 534, and *Circular No.* 3, S. G. O., 1871, p. 91.) Donor, Assistant Surgeon C. S. DeGraw, U. S. A.

10. (**4727.**) Portion of the left scapula of a bison transfixed by a Cheyenne arrow-head. The arrow must have perforated the body of the animal, as the point emerges through the dorsum of the scapula. (See *Circular No.* 3, S. G. O., 1871, p. 160.) Presented by Prof. Joseph Henry.

11. (**4735.**) Section of shaft of seventh rib of a buffalo, with an iron arrow-head impacted. (*Ibid.*, and *Bryant's Manual of Surgery*, 1872, p. 409.) Donor, Prof. Joseph Henry.

12. (**1641.**) Left innominatum and longitudinal half of sacrum, from a soldier of twenty-one years, wounded May 3 and died July 8, 1863. A battered conoidal ball, which perforated the ilium and lodged in the sacrum is attached. (See *Cat.* 1866, p. 228, *Med. and Surg. Hist.*, Part II, Vol. II, p. 217.) Donor, Acting Assistant Surgeon Carlos Carvallo.

13. (**6313.**) Left os innominatum showing a shot perforation of the ilium. The patient died from pyæmia. Donor, Dr. R. B. Bontecou.

14. (**4130.**) Left os innominatum and sacrum perforated by a shell fragment, from a soldier thirty-five years old, wounded April 6, died April 28, 1865, from hemorrhage. (*Cat.* 1866, p. 228, and *Med. and Surg. Hist.*, Part II, Vol. II, p. 223.) Donor, Surgeon J. C. McKee, U. S. A.

15. (**819.**) Round ball impacted near the tuberosity of the right ischium. From case of Private W. L——, Twenty-third North Carolina, wounded at South Mountain September 12, 1862, died, as supposed, from the effects of chloroform, October 28, 1862. (See *Cat.* 1866, p. 224, *Med. and Surg. Hist.*, Part II, Vol. II, p. 242.) Donor, Dr. R. Davies.

16. (**1246.**) Conoidal ball impacted in right ischium. Case of Private S. W——, Twenty-third New Jersey, wounded at Chancellorsville May 3, died of secondary hemorrhage May 24, 1863. (See *Cat.* 1866, p. 227, *Med. and Surg. Hist.*, Part II, Vol. II, p. 242.) Donor, Assistant Surgeon W. Thomson, U. S. A.

17. (**5256.**) Abdominal aorta and branches showing an aneurism of the left common iliac. From a negro man of thirty. The aorta was ligated by Dr. H. McGuire, of Richmond, May 30, 1868. The patient survived the operation eleven hours, the temperature never rising above 96° F. in the axilla. (See *Am. Jour. Med. Sci.*, 1868, Vol. LVI, p. 415; *Circular* 3, S. G. O., 1871, p. 239.) Contributed by the operator.

18. (**3597.**) Aneurismal varix of the left femoral vessels, showing, with the varicose veins and dilated arteries, a portion of the aorta. The iliacs have been successively tied by Acting Assistant Surgeon J. B. Cutter. The patient died September 21, 1864, four days after the ligation of the primitive iliac. (See *Am. Jour. Med. Sci.*, 1864, Vol. XLVIII, p. 36; *Ibid.*, 1865, Vol. L, p. 391; *Cat. Surg. Sect.* 1866, p. 469; *Med. and Surg. Hist.*, Part II, Vol. II, p. 336.) Donor, Assistant Surgeon J. Theodore Calhoun, U. S. A.

19. (**1926.**) A portion of the omentum magnum, in the folds of which is lodged a conoidal bullet which entered the left loin below the twelfth rib, traversed the abdominal muscles to the right side, whence it probably ulcerated through the abdominal wall into the cavity. The patient, a soldier, wounded at Antietam, survived the injury six weeks. (See *Cat.* 1866, p. 490, and *Med. and Surg. Hist.*, Part II, Vol. II, p. 174.) Donor, Dr. W. W. Keen, jr.

III.—Illustrations of Vesical Calculi, chiefly Traumatic.

1. (**5520.**) Vesical calculus successfully removed by median lithotomy, two years after a shot penetration of the bladder, from a soldier, aged forty-two, wounded in front of Petersburg, by Bvt. Col. A. N. Dougherty, U. S. V., medical director of the Second Army Corps. The concretion is reported to have weighed, when extracted, an ounce and twenty-one grains; its present weight is 431 grains (Troy). A layer of uric acid immediately surrounds the ball; the outer investments are of triple phosphate.

2. (**6203.**) Vesical concretion, weighing 580 grains (Troy), consisting of a pistol-ball enveloped in triple phosphates, removed by lateral lithotomy, by Prof. H. McGuire, from a man aged about forty years, who received an accidental shot penetration of the bladder in 1867, and was successfully operated on in December, 1870. (See *Virginia Clinical Record*, 1871, Vol. I, p. 46; *Med. and Surg. Hist.*, Part II, Vol. II, p. 275; *Virginia Med. Monthly*, 1875, Vol. I, p. 543.) Donated by the operator.

3. (**5931.**) Vesical calculus having an iron arrow-head as a nucleus. The concretion weighs 857 grains (Troy). It was successfully removed by lateral lithotomy by Assistant Surgeon W. H. Forwood, U. S. A., at Fort Sill, August 23, 1869, from Satamore, a Kiowa chief, aged forty-two years, wounded through the right sciatic notch near Fort Larned, in 1862, in a fight with Pawnees. (See *Circular* No. 3, S. G. O., 1871, p. 260; *Med. and Surg. Hist.*, Part II, Vol. II, p. 276.) Donor, Dr. W. H. Forwood.

4. (**6282.**) Pistol ball voided by the urethra, by a soldier of the Second Artillery, August 19, 1867, a fortnight after the reception of a shot penetration of the bladder in an affray near the Presidio, Cal. A slight incision with a meatotome permitted the expulsion of the ball, arrested in the fossa navicularis. (See *Med. and Surg. Hist.*, Part II, Vol. II, p. 284.) Donor, Assistant Surgeon J. V. Lauderdale, U. S. A.

5. (**4832.**) Hypertrophied prostate gland and bladder, the latter containing ten large uric acid calculi. The bladder, when removed from an aged man, contained over three hundred hemp-seed vesical calculi; the large concretions are shown *in situ*. Donor, Dr. R. K. Stone.

6. (**4848.**) A mulberry calculus, weighing 1,191.6 grains, successfully removed by lateral lithotomy, August, 1867, by Dr. N. S. Lincoln, in the case of a man of fifty years. (*Richmond and Louisville Med. Jour.*, 1869, Vol. VII, p. 423.) Contributed by the operator.

[*A specimen of salivary calculus is placed with this series.*]

7. (**6204.**) A salivary calculus, formed about a straw, removed from the right duct of steno of a horse. Weight 73.7 grams. Donor, Prof. H. McGuire.

IV.—Illustrations of Injuries of the Upper Extremities.

1. (**3161.**) Head of left humerus excised on account of penetration by a musket-ball, which is impacted. (See *Cat.* 1866, p. 104; *Med. and Surg. Hist.*, Part II, Vol. II, p. 573.)

2. (**6599.**) Head of left humerus, excised for impacted shot fracture, in the case of a soldier of the Ninth Minnesota, wounded at Nashville, December 15, 1864. (*Med. and Surg. Hist.*, Part II, Vol. II, p. 531.) Donor, Dr. A. T. Bartlett.

3. (**4343.**) A segment of the head of the right humerus shattered by shot and secondarily excised, with a good result, showing that such partial excisions are not invariably disadvantageous. (See *Cat.* 1866, p. 97, *Med. and Surg. Hist.*, Part II, Vol. II, p. 527.) Donor, Surgeon R. B. Bontecou, U. S. V.

4. (**1118.**) Upper extremity of right humerus, shattered by a ball and excised intermediarily by Assistant Surgeon C. A. McCall, U. S. A. Case of Private E. H. Woods, Sixth Maine, wounded at Chancellorsville, May 3, 1863. He was fitted with an apparatus by Dr. E. D. Hudson, who reported in 1865 that the diaphysis had been partially reproduced. (See *Cat.* 1866, p. 109, *Med. and Surg. Hist.*, Part II, Vol. II, p. 580.) Contributed by the operator.

5. (**5657.**) Portions of the right humerus, including the head and a greater part of the shaft, excised at different periods for caries following perforation by a conoidal ball, about 3 inches below the shoulder. The first operation was performed eighteen and a half months after the injury, by Dr. E. Andrews, late surgeon First Illinois Artillery, and the other specimens sixteen and eighteen months later, by the donor. The remainder of the humerus has been removed since. The subject was a pensioner, and died ten years and nine months after the original injury. (See *Med. and Surg. Hist.*, Part II, Vol. II, p. 594; *Chicago Med. Journal*, 1871, Vol. XXVIII, p. 326.) Donor, Dr. C. M. Clark, late surgeon Thirty-ninth Illinois.

6. (**734.**) The left elbow joint excised by Surgeon I. Moses, U. S. V., for a shot fracture of the inner condyle of the humerus. The patient recovered and was pensioned. (See *Cat.* 1866, p. 161, *Med. and Surg. Hist.*, Part II, Vol. II, p. 890.) Contributed by the operator.

7. (**4249.**) The tip of the olecranon and three inches of the lower extremity of the left humerus, successfully excised by Assistant Surgeon A. W. Campbell, Eleventh New York Cavalry, for compound fracture caused by a fall from a horse. (See *Cat.* 1866, p. 159.) Donor, Dr. M. D. Benedict.

8. (**6461.**) The lower third of the left humerus and the upper thirds of the ulna, showing an ununited fracture in the upper third of the ulna, about 2 inches below the elbow joint. This specimen was purchased with the Gibson cabinet.

9. (**6443.**) An ulna, the diaphysis and epiphyses necrosed throughout, excised from a negro fifty years of age, July 14, 1874. Contributed by the operator, Dr. N. S. Lincoln.

10. (**6588.**) A wet preparation of a dissection of the right forearm, from a man of fifty years, who died at Fort Sill, November 13, 1875. An ununited fracture was known to have existed for more than five years. The ununited extremities of the radius and ulna are rounded off, and the expanded muscular fasciculi form a pseudo-capsule. The forearm was quite serviceable during life. Donor, Surgeon F. L. Town, U. S. A.

11. (**531.**) The right radius, showing a simple consolidated fracture with slight angular displacement without shortening. This specimen, which is more than two hundred years old, was picked up upon an ancient battle field on Oaku, Sandwich Islands. (*Cat.* 1866, p. 194.) Donor, Assistant Surgeon W. R. DeWitt, jr., U. S. V.

12. (**5251.**) A remarkable instance of reproduction of the metacarpal and phalangeal bones after necrosis. The clinical history is unknown. Purchased with the Gibson cabinet.

V.—Illustrations of Injuries of the Lower Extremities.

1. (**5691.**) Upper portion of the right femur, fractured in the upper third by a conoidal ball. From a soldier of the Seventh Infantry, aged twenty-three, wounded May 6, 1870. A fissure extends into the hip-joint. Loose fragments of bone were removed. The patient succumbed on the third day after the injury. (See *Circ.* 3, 1871, p. 70.) Contributed by Assistant Surgeon J. Basil Girard, U. S. A.

2. (**86.**) The upper third of the right femur, fractured by a conoidal ball, which entered from the front and perforated the bone at the base of the neck, lodging in the great trochanter, and producing a longitudinal fracture extending to the articulation and reaching 6 inches down the shaft. The patient died twelve days after the injury. (See *Cat.* 1866, p. 236, and *Circ.* No. 2, S. G. O., 1869, p. 81.) Donor, Dr. J. P. Arthur.

3. (**3520.**) The upper fifth of the right femur, sawn longitudinally, showing a penetrating fracture of the neck by a pistol-ball, which lodged, exposing its surface just within the capsule. The injury resulted in suppurative destruction of the joint. The patient survived the injury two months. (See *Cat.* 1866, p. 235, and *Circ.* No. 2, S. G. O., 1869, p. 114.) Donor, Assistant Surgeon W. Thomson, U. S. A.

4. (**5518.**) A portion of the right os innominatum and the upper fourth of the femur, showing chronic traumatic arthritis of the hip-joint following a gunshot injury. The patient died of morbus Brightei seven years after being wounded. (See *Circ.* No. 2, S. G. O., 1869, p. 93.) Donor, Assistant Surgeon J. H. Janeway, U. S. A.

5. (**5920.**) The right os innominatum and part of femur, supposed to present an intra-capsular fracture of the neck of the femur. This specimen was found in a dissecting-room at Omaha Barracks, Nebr. Donor, Assistant Surgeon F. Meacham, U. S. A.

6. (**128.**) The upper fourth of the right femur, showing deformity of the neck from chronic arthritis. The specimen has been thought to simulate consolidated intra-capsular fracture. (See *Cat.* 1866, p. 312.) Donor, Assistant Surgeon B. E. Fryer, U. S. A.

7. (**6596.**) The right femur, showing an united shot fracture in the upper third. The patient recovered from this injury, which was inflicted September 19, 1864; but while at the National Home for Disabled Volunteer Soldiers, at Hampton, Va., in February, 1876, he fell upon his disabled thigh, and extensive inflammation and suppuration resulted, and caused death in a few days. Donor, Dr. W. M. Wright, surgeon in charge.

8, 9. (**3881-'82.**) Specimens representing united shot fractures in both thigh-bones. The right femur united, 2 inches shortened, after fracture in the upper third. The left with 2½ inches shortening and angular deformity. The patient survived these injuries seven months and thirteen days. (*Cat.* 1866, pp. 265, 279.) Donor, Acting Assistant Surgeon G. M. Paullin.

10. (**3394.**) Upper portion of the left femur, badly comminuted by shot below the trochanters and united with displacement and profuse deposit of callus. A number of large fragments preserved their life, to connect the broken shaft. From a soldier in a Nashville hospital. (*Cat.* 1866, p. 281.) Donor, Assistant Surgeon C. C. Byrne. U. S. A.

11. (**6571.**) The right femur, fractured in the upper third by a rifle-ball. Three or four fragments of bone were removed by Dr. McClelland, of Denver. The patient survived the injury thirteen years, an almost constant purulent discharge continuing during this period. Donor, Assistant Surgeon J. H. Patzki, U. S. A.

12. (**4201.**) Upper half of the left femur, contused by shot at the junction of the upper thirds. An exfoliation at the seat of injury is nearly separated; the posterior surface is eroded. The patient, a soldier of the One hundred and ninety-first Pennsylvania, aged thirty years, survived the injury forty-seven days. (*Cat.* 1866, p. 258.) Donor, Assistant Surgeon W. F. Norris, U. S. A.

13. (**3540.**) Upper third of the left femur, longitudinally bisected, with an impacted pistol ball in the base of the neck. The patient survived the injury seventy-two days. (*Cat.* 1866, p. 260, *Circular* 2, 1869, p. 71.) Donor, Assistant Surgeon W. Thomson, U. S. A.

14. (**1907.**) The left femur comminuted in the center of the shaft by a conical ball, which previously passed through the right thigh, and is attached to the specimen much flattened. The patient survived the injury sixteen days. (*Cat.* 1866, p. 267; *Circular* 6, S. G. O., 1865, p. 33.) Donor, Acting Assistant Surgeon J. Cass.

15. (**1354.**) The left femur, firmly united, with an inch shortening and slight lateral deformity, after a fracture in the middle third by a conoidal ball. The large fragments that were split off occupy the place of splints held by the callus. The point of fracture shows portions of dead bone not yet thrown off. The patient, Private J. W ——, Twenty-first Georgia, aged thirty-eight, wounded at Fort Steadman, March 25, 1865, survived the injury one hundred and eighty-two days. Dr. G. K. Smith, who treated the case at Armory Square Hospital, regarded it as an example of recovery, and the patient was photographed five months after injury at the Museum. (*Surg. Series of Phot.*, S. G. O., Vol. II, p. 42; see also *Cat.* 1866, p. 270.) Donor, Assistant Surgeon W. F. Norris, U. S. A.

16. (**2182.**) The left femur, fractured at the junction of the middle and lower thirds by a conical ball. The displaced fractured ends of the shaft have been connected by arches of callus. From a soldier of a Kentucky regiment, who survived the injury forty-nine days. (*Cat.* 1866, p. 270.) Donor, Acting Assistant Surgeon R. T. Higgins.

17. (**5484.**) Two femurs, the right showing consolidated simple fracture; its fellow is mounted with it to show the extent of shortening. This specimen was found with a number of skeletons, believed to belong to a prehistoric race allied to the Esquimaux, in a tumulus near Fort Wadsworth, Dak., explored by the donor, Dr. A. I. Comfort. (See *Report of Smithsonian Institution*, 1871, p. 389.)

[*Many illustrations of consolidated fractures of the femur after shot injury will be found in the volumes of surgical photographs sent to the International Exhibition at Philadelphia. The preparations of this class were for the most part so fragile that it was thought inexpedient to expose them to the hazards of transportation.*]

[*The next four specimens illustrate excisions at the hip.*]

18. (**3375.**) Upper portion of the right femur, successfully excised by Assistant Surgeon G. A. Mursick, U. S. V., for shot comminution, in the case of Private H. Wright, Eighth New Jersey, aged twenty-eight, wounded at the Wilderness May 5, excised May 27, 1864. The patient recovered, and walks without assistance or noticeable lameness. (*Circ.* 6, S. G. O., 1865, p. 68; *New York Med. Jour.*, 1865, Vol. I, p. 424; *Cat.* 1866, p. 246; *Circ.* 2, 1869, p. 41.) Contributed by the operator.

19. (**5499.**) The head and upper portion of the shaft of the right femur, for fracture by a musket ball, by Prof. C. B. Gibson, in the case of a soldier [illegible] Sixty-first Virginia regiment, wounded at the Wilderness May 6, 1864. The pa[illegible] survived the operation four days. (See *Circ.* No. 2, S. G. O., 1869, p. 27.) Donor, D[illegible] W. F. Richardson.

20. (**5576.**) Carious head of left femur with a musket-ball impacted, excised August 14, 1868, ten months after injury, in the case of Private C. F. Reed, Thirty-seventh Infantry, aged twenty-one. He made an excellent recovery, and walks with only a slight limp. (See *Circ.* No. 2, 1869, p. 117, and *Circ.* No. 3, 1871, p. 228, S. G. O.) Assistant Surgeon J. R. Gibson, U. S. A.

21. (**5658.**) The head, neck, and portion of the shaft of the left femur, shattered by a musket-ball December, 1869, near Fort Laramie, and excised the following day by Assistant Surgeon F. Meacham, U. S. A. The patient, a soldier of the Fourth Infantry, aged forty-eight, recovered and was discharged. (See *Circ.* No. 3, S. G. O., 1871, p. 230.) He afterwards entered Soldiers' Home, became insane, and died at the Government Insane Asylum November 7, 1871.

[*The four following preparations illustrate amputations at the hip.*]

22. (**4237.**) Upper two-thirds of the right femur, amputated at the hip-joint by Surgeon E. Griswold, U. S. V., April 12, 1865, for an oblique shot fracture at the base of the great trochanter, with a complete longitudinal fracture extending eight inches down the shaft, in the case of a soldier of the Second New York Mounted Rifles, aged seventeen, wounded March 31, 1865. The patient survived the operation less than an hour. (*Circ.* 6, 1865, pp. 50 and 72; *Cat.* 1866, p. 248; *Circ.* 7, 1867, p. 39.) Donor, Surgeon E. Griswold, U. S. V.

23. (**4386.**) The left femur amputated at the hip-joint by Surgeon E Bentley, U. S. V., for complications resulting from an imperfectly united shot fracture at the junction of the upper thirds, in the case of Private G. W. L——, Sixth Maryland, aged thirty, wounded May 5, 1864, and amputated October 12, 1865. The patient recovered and was pensioned. (*Cat.* 1866, p. 248; *Circ.* 7, 1867, p. 42.) Donor, Surgeon E. Bentley, U. S. V.

24. (**5684.**) The upper portion of the left femur exarticulated on account of osteomyelitis nearly six years after primary amputation of the leg, and consecutive amputation through the condyles, in the case of a soldier of the Fourth Artillery, aged thirty-eight. The patient recovered, and is now (June, 1876) in good health. (See *Circ.* No. 3, S. G. O., 1871, p. 215; *Am. Jour. Med. Sci.*, 1871, Vol. LXI, p. 141.) Donor, Assistant Surgeon G. A. Otis, U. S. A.

25. (**252, 4954, 5946.**) Private W. C.——, Seventh New Hampshire, was wounded at Petersburg July 30, 1864, and amputated primarily. Osteomyelitis ensued, and, November 29, 1864, Assistant Surgeon W. Thomson, U. S. A., extracted the cylindrical sequestrum (*Spec.*, 252), and on June 6, 1866, resected several inches of the shaft, affected with ostoeporosis (*Spec.*, 4954). The patient was discharged October 15, 1866, the stump still in a diseased condition. On October 15, 1871, Dr. N. S. Lincoln exarticulated the remaining portion of the femur, by an incision on the outer aspect of the thigh, without implicating the important blood-vessels. The patient recovered and was pensioned, and entered the National Military Asylum at Hampton. He died while on furlough at Queenstown, Ireland, January 1, 1874.

[*The next series illustrates primary or ulterior lesions in the shaft of the femur, amputated for shot injury.*]

26. (**4120.**) The lower half of the right femur, amputated primarily by Surgeon D. S. Hays, One hundred and tenth Pennsylvania, for a severe shot comminution by a conical ball, which has flattened in a mushroom shape against the anterior surface of the lower third. The patient, a soldier of the Seventy-third New York, aged forty-six years, wounded September 11, 1864, recovered and was pensioned. (*Cat.* 1836, p. 256.) Contributed by the operator.

27. (**1413.**) The lower half of the right femur, amputated for a transverse shot fracture in the middle third by a conical ball, which is attached, flattened. A very small portion of the laminated structure is wanting at the point of impact on the outer surface, and directly opposite a longitudinal fissure extends into both fragments. (*Cat.* 1866, p. 225.) Donor, Surgeon C. S. Wood, Sixty-sixth New York.

28. (**30.**) Lower half of the right femur, amputated a fortnight after shot fracture in the middle third, by Assistant Surgeon J. S. Billings, U. S. A. The patient, a soldier, wounded at Williamsburg May 5, 1862, recovered. (*Cat.* 1866, p. 285.) Contributed by the operator.

29. (**3875.**) Portion of the left femur, amputated one month after injury in the upper third, by Assistant Surgeon R. F. Weir, U. S. A., for shot comminution in the middle third with a very oblique fracture. The patient, Private J. F——, First New York Cavalry, aged twenty-one, was wounded July 7, 1865, and died twelve days after the operation. (*Cat.* 1866, p. 289.) Donor, Acting Assistant Surgeon J. H. Bartholf.

30. (**4067.**) Greater portion of the shaft of the right femur, amputated in the upper third nine days after injury, by Surgeon N. R. Moseley, U. S. V., for a shot fracture in the middle third, with extensive longitudinal fissures, by a conical ball, which is attached, flattened. The patient, a soldier of the One hundred and ninety-eighth Pennsylvania, aged twenty, survived the operation six days. (*Cat.* 1866, p. 288.) Contributed by the operator.

31. (**2039.**) Lower half of the left femur, amputated five days after injury, by Surgeon J. Aiken, Seventy-first Pennsylvania, for a shot comminution in the middle third by a conical ball, which is attached. The patient, Private P. M——, Thirty-ninth New York, wounded February 6, 1864, is a pensioner. (*Cat.* 1866, p. 256.) Contributed by the operator.

32. (**3518.**) *A post-mortem* specimen, exsected from the stump of the left femur, after a primary amputation above the knee for shot injury, by Assistant Surgeon J. C. McKee, U. S. A., Private T. T——, Twelfth Georgia, aged twenty-nine, wounded near Washington, and amputated two days after injury, survived the operation about six months. The tubular sequestrum, inclosed in a bulky involucrum, shows in an exaggerated form the alterations in bones protruding from stumps. (*Cat.* 1866, p. 310.) Donor, Acting Assistant Surgeon H. M. Dean.

33. (**536.**) Lower half of right femur, exhibiting an osteoplastic operation by Assistant Surgeon J. W. S. Gouley, U. S. A., for a shot fracture of the femur involving the knee-joint, in the case of a soldier of the Fifth New Hampshire, aged twenty, wounded at Fredericksburg December 13, 1862. Amputated in the middle third by Surgeon J. P. Prince, Thirty-sixth Massachusetts, three days subsequently, for hemorrhage from the popliteal. The patient survived the last operation twelve days. (*Cat.* 1866, p. 293; *Boston Med. and Surg. Journ.*, Vol. 68, p. 69.) Donor, Surgeon J. P. Prince, Thirty-sixth Massachusetts.

34. (**406.**) Lower third of the left femur of a soldier of Morgan's Partisan Cavalry, amputated by Dr. V. B. Thornton, for a partial fracture by a conoidal ball, which is imbedded just above the patella. The patient recovered. (*Cat.* 1866, p. 283.) Donor, Acting Assistant Surgeon F. Schafhirt.

35. (**576.**) The lower third of the right femur, amputated for inflammation of the knee, following a partial fracture from a spherical iron ball, which is lodged in the anterior face of the outer condyle. (*Cat.* 1866, p. 352.) Donor, Dr. G. Welles.

36. (**319.**) The lower third of the right femur, amputated six days after injury for perforation above the condyles by a round ball, in the case of a soldier of the Twenty-fifth Ohio, who died forty-five days after the opera ion. (*Cat.* 1866, p. 353.) Contributed by the operator, Surgeon J. E. Summers, U. S. A.

[*The next two specimens are of amputations remotely after consolidated shot fractures.*]

37. (**4914.**) Lower half of left femur, showing a consolidated fracture in the lower third. From a soldier, twenty-four years of age, of the Twenty-seventh Indiana, wounded at Antietam September 17, 1862, and discharged as cured December 7, 1863. Frequent detachments of osteophyte and necrosed bits of bone kept up a perpetual suppuration, and the pensioner asked to have his limb removed. It was amputated November 11, 1867, five years after injury, by Dr. D. W. Bliss, and rapid recovery ensued. (*Circ.* No. 3, S. G. O., 1871, p. 205.) Contributed by the operator.

38. (**5558.**) Lower three-fifths of right femur, showing a consolidated shot fracture in the middle third, with a fragment of ball impacted in the callus. Private J. M. J——, Twenty-first Indiana, aged twenty-nine, was wounded at Baton Rouge August 5, 1862, treated conservatively, and discharged August 15, 1863. Although the fracture had united with great deformity, there was such constant suffering from exfoliations, abscess formations, and burrowing of pus, that the pensioner demanded the removal of the limb. Amputation just above the seat of injury was practiced by Dr. D. W. Bliss.

[*Several succeeding specimens illustrate diseased stumps, particularly osteomyelitis and the necrosed sequestræ frequently found after amputation.*]

39. (**2602.**) An involucrum of 3 inches and a tubular sequestrum of 7 inches in length, extracted from a stump of the right femur three months after amputation in the lower third, in the case of a soldier of the Fourth Pennsylvania Cavalry, aged twenty-four, wounded at Upperville June 21, 1863, and amputated twelve days subsequently by Assistant Surgeon P. C. Davis, U. S. A. (*Cat.* 1866, p. 309.) Dr. C. B. King resected the diseased stump, and presented the specimen.

40. (**2232.**) A heavy tubular sequestrum, nearly 5 inches in length, removed from the stump of the left femur by Surgeon B. A. Vanderkieft, U. S. V., six months after amputation at the junction of the upper thirds for a shell fracture of the middle third. The patient, Private J. F——, Fifteenth Massachusetts, aged thirty-five, was wounded October 14, and amputated October 26, 1863, and the sequestrum was removed April 1, 1864. (*Cat.* 1866, p. 306.) Donor, Surgeon W. S. Ely, U. S. V.

41. (**107.**) A cylindrical sequestrum 2½ inches long from a stump of the left femur, amputated in the middle third for shot comminution of the lower third (*Spec.* 3734, *Surg. Sect.* A. M. M.) by Acting Assistant Surgeon E. G. Waters. The patient, Sergeant E. U——, Fifteenth New Jersey, was wounded October 19, 1864, at Cedar Creek, and amputated November 14, 1864. March 8, 1865, the sequestrum was removed by Acting Assistant Surgeon B. B. Miles. Exarticulation at the hip was successfully performed by Dr. T. G. Morton, February 17, 1866. (See *Circ.* 7, S. G. O., 1867, p. 51; *Cat.* 1866, p. 305; *Am. Jour. Med. Sci.*, 1866, Vol. LII, p. 17.) Donor, Dr. B. B. Miles.

42. (**4281.**) A sequestrum of 8 inches, removed from the stump of the left femur three months after primary amputation for shot injury. The patient, a soldier of the Sixth New York Cavalry, aged twenty-three, wounded and amputated May 7, 1864, recovered. (*Cat.* 1866, p. 309.) Donor, Assistant Surgeon W. Thomson, U. S. A.

43. (**171.**) A sequestrum, 8½ inches long, removed from the stump of the left femur two months after intermediary amputation in the lower third for shot injury. The patient, a corporal of the Sixty-fourth New York, aged thirty, wounded at Hatcher's Run March 25, 1865, recovered. (*Cat.* 1866, p. 309.) Donor, Assistant Surgeon H. Allen, U. S. A.

44. (**3698.**) Necrosed stump of left femur, surrounded by a firm and uniform deposit of callus, removed, on account of protrusion, seven weeks after primary amputation for a railroad accident. The patient, a soldier of the Twelfth Wisconsin, recovered. (*Cat.* 1866, p. 294.) Donor, Surgeon H. Culbertson, U. S. V.

[*The next series illustrate shot injuries of the knee.*]

45. (**3269.**) Bones of the right knee, after amputation in the lower third of the thigh, by Surgeon N. R. Moseley, U. S. V., for shot fracture of the tibia and fibula,

in a case in which Dr. W. H. Ensign had excised the upper portion of the fibula for gangrene and hæmorrhage. The patient, a private of the One hundred and seventieth New York, aged forty-four (wounded August 25, excised September 12, amputated September 18, 1864), survived the amputation three days. (*Cat.* 1866, p. 381.) Donor, Dr. H. G. Bates.

46. (**4135.**) The upper extremity of the bones of the left leg, fractured by a conoidal ball which perforated from within and below, splintering the head of the tibia and resting on the articulation. The patient, Private T. J. T——, Fifty-seventh Massachusetts, was wounded March 25, amputated March 30, and discharged on October 30, 1865, and furnished with an artificial limb. (*Cat.* 1866, p. 319.) Donor, Surgeon W. O. McDonald, U. S. V.

47. (**1882.**) The bones of the right knee, amputated in the lower third of the femur by Surgeon A. N. Dougherty, U. S. V., in the case of Private W. G. M——, Fourth Ohio, wounded at Mine Run, November 27, amputated December 3, 1863, for a shot fracture of the outer condyle and the head of the tibia. A conoidal ball, compressed upon itself, is lodged in the latter bone. The patient is a pensioner. (*Cat.* 1866, p. 348.) Donor, Surgeon J. Dwinelle, One hundred and sixth Pennsylvania.

48. (**2276.**) The bones of the left knee, amputated in the lowest third of the thigh for fracture of the internal condyle of the femur and of the head of the tibia by a conoidal ball, which is impacted in the latter. The patient, Private L. R——, Twenty-third North Carolina, aged thirty-four, wounded at Spottsylvania May 12, was amputated May 14, 1864, and died of pyæmia eleven days after the operation. (*Cat.* 1866, p. 345.) Donor, Surgeon O. A. Judson, U. S. V.

[*A specimen of ligamentous union is selected from the series of united simple fractures of the patella.*]

49. (**5364.**) The bones of the right knee-joint, showing a transverse fracture of the patella with ligamentous union. (From the Gibson Cabinet.)

[*The next series is of shot injuries of the bones of the leg.*]

50. (**4387.**) The right tibia and fibula, from a case of amputation in the lower third of the thigh six months after shot fracture in the leg. Tolerable union has occurred in the fibula. The tibia is partly united, is carious at the point of fracture, and has a very large and complete foliaceous deposit throughout its greatest length. The patient, a sergeant of the Second Maryland, aged twenty-four, was wounded April 2, and amputated October 14, 1865, and recovered. (*Cat.* 1866, p. 392.) Donor, Surgeon E. Bentley, U. S. V.

51. (**1335.**) Right tibia and fibula, comminuted by a 12-pound cannon shot at Gettysburg, July 3, 1863. Primary amputation above the knee was performed by Surgeon T. Sim, U. S. V. The patient rapidly recovered, and was able to ride out in a fortnight. (*Circ.* No. 6, S. G. O., 1865, p. 38; *Cat.* 1866, p. 373.) Contributed by Maj. Gen. D. E. Sickles, the officer mutilated.

52. (**3604.**) The right tibia and fibula, comminuted by a musket ball at Port Hudson, May 27, 1863. The patient, Brig. Gen. T. W. S——, U. S. V., was amputated above the knee a few weeks after the injury by Dr. W. Stone, and recovered. (*Circ.* No. 6, S. G. O., 1865, p. 38; *Cat.* 1866, p. 393.) Donor, Prof. C. Bacon, of Yale.

53. (**6581.**) Fragments of the bones of the left leg and ends of condyles of the femur, and a piece of a small bursted swivel gun that inflicted the injury. Primary amputation at the knee-joint resulted in a good stump. Case of Private G. G——, Second Infantry, wounded July 4, 1875. The pensioner is at Soldiers' Home. Donor, Assistant Surgeon J. K. Corson, U. S. A.

54. (**1022.**) The upper extremity of the left tibia, in the spongy portion of which a buckshot was embedded, which was extracted. The patient, a private of the Eleventh Pennsylvania, wounded at Fredericksburg, died three weeks after the injury, of pyæma. (*Cat.* 1866, p. 262.) Donor, Dr. G. F. French.

55. (**1956.**) Head of left tibia and condyles of the femur, excised five months after fracture by a spherical ball, which is lodged in the inner condyle. The patient died from pyæmia twenty-two days after the operation. (*Circ.* No. 6., S. G. O., 1865, p. 59; *Cat.* 1866, p. 335.) Contributed by the operator, Dr. F. Hinkle.

56. (**2778.**) Upper portions of the tibia and fibula of the right leg, with hyperostosis of the distal extremities of both bones. From a soldier of the Fifty-first Pennsylvania, wounded at White Oak Swamp June 30, 1862. (See *Cat.* 1866, p. 400.) Donor, Dr. T. G. Morton.

57. (**1916.**) The bones of the left leg after shot contusion of the tibia by a musket ball. The patient, Corporal H. C——, Twenty-first Michigan, wounded at Murfreesborough December 3, 1862, died five months after the injury. (See *Cat.* 1866, p. 375.) Donor, Assistant Surgeon C. C. Gray, U. S. A.

58. (**3588.**) The left tibia, two and a third months after longitudinal shot fracture of the shaft, and consecutive necrosis. Corporal J. D——, One hundred and sixty-fourth New York, aged forty-eight, was wounded at Cold Harbor June 3, and died August 18, 1864. (*Cat.* 1866, p. 375.) Donor, Assistant Surgeon W. Thomson, U. S. A.

59. (**3337.**) The bones of the right leg with 2½ inches of the middle third of the tibia excised, and showing dead bone for an inch on each side of the excision. Amputation at the middle third of the thigh for gangrene was practiced a month after the injury. The patient survived the operation two days. Case of Private N. R——, One hundred and fifty-fifth Pennsylvania, aged twenty-seven. (*Cat.* 1866, p. 382.) Donor, Surgeon E. Bentley, U. S. V.

60. (**1526.**) Six inches of the stumps of the bones of the left leg, reamputated for necrosis of the tibia, showing a massive involucrum, except on the anterior border, where a heavy sequestrum is visible. Case of Private J. C——, Seventh Wisconsin, aged twenty-one, wounded June 18, amputated June 19, 1864, and reamputated February 25, 1865. The patient recovered. (*Cat.* 1866, p. 397.) Donor, Surgeon B. B. Wilson, U. S. V.

61. (**4740.**) Stumps of the left tibia and fibula, reamputated for necrosis 3 inches below the knee, nearly nine months after amputation above the ankle. Both bones present large involucra inclosing cylindrical sequestræ. The patient, Private O. P——, Twenty-eighth Colored Troops, aged nineteen, wounded June 7, amputated June 27, 1864, and reamputated March, 1865, recovered. Donor, Surgeon T. W. Fry, U. S. V.

62. (**2594.**) The bones of the right leg, amputated in the middle third seven months after fracture in the lowest third, the fibula being firmly consolidated, and much callus being effused about the tibia, but caries having prevented firm union. The patient recovered, and was furnished with an artificial leg. (*Cat.* 1866, p. 385.) Donor, Assistant Surgeon C. R. Greenleaf, U. S. A.

63. (**6569.**) The lower two-thirds of the right tibia and fibula successfully amputated for disease nearly ten years after gunshot fracture, by Dr. J. F. M. Forwood, of Chester, Pa., in the case of Private L. O. B——, First Delaware, nineteen years of age, who was wounded at Antietam. Contributed by the operator.

64. (**481.**) The lower portions of the bones of the right leg amputated ten and a half months after perforation of the tibia by a conoidal ball, in the case of Private E. C——, Third Mississippi, aged twenty-two, wounded at Peach Tree Creek July 20, 1864. (*Cat.* 1866, p. 384.) Donor, Surgeon S. Kneeland, U. S. V.

65. (**2454.**) Three inches of the right tibia and fibula resected four months after a primary amputation near the ankle, for shot injury in the case of Private C. F——, One hundred and eleventh New York, aged nineteen, wounded March 11, 1865. (*Cat.* 1866, p. 398.) Donor, Surgeon B. B. Wilson, U. S. V.

[*The next two specimens are from cases of simple fracture in the leg.*]

66. (**6341.**) The right tibia and fibula seven months after simple fracture at diagonally opposite points in the two shafts. Union took place, and the patient recovered with but slightly perceptible shortening. He died several months afterwards with aneurism of the aorta. Case of Artificer J. M——, Engineer Battalion. The fracture occurred July 27, 1866, and death March 2, 1867. Donor, Surgeon B. J. D. Irwin, U. S. A.

67. (**6516.**) Amputated portions of bones of the left leg, in the case of a lad of nineteen years, who had a simple fracture in his first year. The bones united with such malposition that the foot was directly reversed. Dr. S. D. Turney, who presented the specimen, was the operator. The patient recovered.

[*A single example of operative interference for disease of the tibia is introduced.*]

68. (**1915.**) A sequestrum, nearly 12 inches in length, from the right tibia of Private W. F——, eighty-fifth Illinois, aged twenty-four. (*Cat.* 1866, p. 408.) Donor, Surgeon C. W. Hornor, U. S. V.

[*Illustrations of shot injuries, diseases, and operations at the ankle follow.*]

69. (**3607.**) Bones of right ankle, amputated thirteen and a half months after injury by a ball which entered 6 inches above the ankle-joint and escaped at the point of the heel. The patient, a private of the forty-fourth Ohio, wounded at Missionary Ridge, recovered. (*Cat.* 1866, p. 435.) Donor, Assistant Surgeon G. M. Sternberg, U. S. A.

70. (**3356.**) Ligamentous preparation of the right tarsus and metatarsus, one month after injury, with a conoidal ball lodged in the carious astragalus. Case of Private C. H., thirty-third Massachusetts, wounded at Dallas May 25, 1864. Amputated June 26, 1864. (*Cat.* 1866, p. 428.) Donor, Dr. L. B. McNabb.

71. (**2783.**) Portions of the right tibia, fibula, astragalus, and calcaneum, from a successful Pirogoff's amputation. From Private O. C——, seventeenth Wisconsin, wounded at Gettysburg July 1, 1863. (*Cat.* 1866, p. 422.) Contributed by the operator, Acting Assistant Surgeon A. Hewson.

72. (**854.**) Ligamentous preparation of the bones of the left foot, from a case of talipes. A. B——, colored, aged twenty-three, died in hospital at Washington November 20, 1866. Donor, Hospital Steward A. M. Squier, U. S. A.

73. (**4543.**) The left astragalus and lower borders of the tibia and fibula, from a soldier shot through the ankle at Fredericksburg December 12, 1862, and amputated by a modification of Syme's method.

74. (**828.**) The left metatarsus, scaphoid, cuboid, and outer cuneiform bones, with conoidal bullet in the place of the inner cuneiform. Amputated by Syme's method by Surgeon J. W. Wishart, One hundred and fortieth Pennsylvania, in the case of Private H. E. B——, first Massachusetts Artillery, wounded at Spottsylvania, May 19, 1864. (*Cat.* 1866, pp. 127, 413; *Med. and Surg. Hist.*, Part II, Vol. II, p. 683.) Contributed by the operator.

75. (**6266.**) Bones of left foot, amputated June 8, 1873, for gelatinous arthritis of the tibia-tarsal articulation, in the case of Pensioner W. J——, Soldiers' Home, by Acting Assistant Surgeon J. D. Barnes. The tibia and fibula became diseased, and reamputation at the place of election was practiced December 21, 1873. On recurrence of disease of the bones of the stump reamputation at the knee-joint was practiced May 15, 1875, by the same operator. Donor, Dr. J. D. Barnes.

[*The foregoing memoranda briefly refer to the specimens sent to Philadelphia from the pathological branch of the surgical section, and indicate wherein fuller information may be found. Of the many other objects pertaining to the surgical section exhibited in the representation of the Army Medical Department, some, as the series of photographs deposited in room 4, or suspended from the walls, were accompanied by printed descriptions, and others, such as the surgical instruments now issued to Army medical officers, those used in the Revolution, the war of* 1812, *the war with Mexico, and the late civil war, together with drawings and models*

of the means of transport of wounded by land or water, or the various appliances that make up the materia chirurgica of the Army surgeon, either had attached labels or were described in other pamphlets.]

No. 20. One black-walnut case containing two exhibition microscopes, made by J. W. Queen & Co., of Philadelphia, with objectives by J. R. Beck, of London. They had placed under each daily a specimen selected from the following list of preparations which were intended as samples of the microscopical section of the Army Medical Museum. Any of the preparations in the list were to be seen on application to Dr. H. C. Yarrow, Room No. 7, who placed a suitable microscope and the preparations at the service of visitors acquainted with the use of the instrument. These slides were exhibited as samples of the preparations in the microscopical section of the Army Medical Museum, which now number 7275.

LIST OF MICROSCOPICAL PREPARATIONS.

No. 1. (No. 419 Mic. Sect.) Perpendicular section of ileum, with enlarged solitary glands. Intestinal catarrh.

No. 2. (No. 466 Mic. Sect.) Perpendicular section of ileum, with a follicular ulcer. Intestinal catarrh.

No. 3. (No. 1699 Mic. Sect.) Perpendicular section of ileum, showing typhoid thickening of a Peyer's patch.

No. 4. (No. 648 Mic. Sect.) Perpendicular section of colon, showing enlarged solitary glands. Intestinal catarrh.

No. 5. (No. 678 Mic. Sect.) Perpendicular section of colon coated with pseudo-membrane. Diphtheritic dysentery.

No. 6. (No. 6108 Mic. Sect.) Perpendicular section of ileum, showing ulcers of the solitary glands. Intestinal catarrh.

No. 7. (No. 711 Mic. Sect.) Perpendicular section of colon, to show the edge of a large ulcer. Dysentery.

No. 8. (No. 878 Mic. Sect.) Perpendicular section of human skin, to show a small-pox pustule.

No. 9. (No. 6694 Mic. Sect.) Perpendicular section of skin of calf, to show the vaccine vesicle one hundred and forty-four hours after inoculation.

No. 10. (No. 6650 Mic. Sect.) Perpendicular section of skin of calf, to show vaccine vesicle forty-eight hours after inoculation.

No. 11. (No. 4277 Mic. Sect.) Perpendicular section of stomach of mare: case of gastro-enteritis with commencing peritonitis. A small vein in the sub-peritoneal connective tissue is surrounded with a swarm of migrated white corpuscles.

No. 12. (No. 7192 Mic. Sect.) Transverse section of stomach of frog, to show gastric glands.

No. 13. (Not catalogued.) Section of ovary of cat, showing Graafian follicles and ovules.

Nos. 14 and 15. (Not catalogued.) Silver staining of the endothelium of the blood-vessels of the bladder of the frog, with carmine staining of the nuclei.

No. 16. (No. 3246 Mic. Sect.) Silver staining of epithelium of skin of frog.

No. 17. (No. 4676 Mic. Sect.) Muscle of rat. Carmine injection.

No. 18. (No. 4602 Mic. Sect.) Lung of frog. Capillaries injected with nitrate of silver, and nuclei stained with carmine.

No. 19. (No. 3224 Mic. Sect.) Transverse section of jejunum of cat. Capillaries injected with Prussian blue, nuclei stained with carmine.

No. 20. (Not catalogued.) Muscle of rat. Capillaries injected with carmine.

No. 21. (No. 6538 Mic. Sect.) Papillary wart from abdomen.
No. 22. (No. 3884 Mic. Sect.) Condyloma. See No. 48.
No. 23. (No. 4606 Mic. Sect.) Lipoma from the groin.
No. 24. (No. 2157 Mic. Sect.) Section of goitre.
No. 25. (No. 2624 Mic. Sect.) Sarcoma of mesentery.
No. 26. (No. 5605 Mic. Sect.) Exostosis of tibia.
No. 27. (No. 6133 Mic. Sect.) Melanotic growth from back.
No. 28. (No. 4656 Mic. Sect.) Epithelioma of leg.
No. 29. (No. 6085 Mic. Sect.) Epithelioma of leg (to show "corps concentriques").
No. 30. (No. 4754 Mic. Sect.) Epithelioma of lip.
No. 31. (No. 5861 Mic. Sect.) Epithelioma of lip to show invasion of muscle.
No. 32. (Not catalogued.) Papillary growth of uvula.
No. 33. (No. 2387 Mic. Sect.) Epithelioma of larynx.
No. 34. (Not catalogued.) Epithelioma of lachrymal gland.
No. 35. (No. 5904 Mic. Sect.) Medullary carcinoma of parotid.
No. 36. (No. 6464 Mic. Sect.) Myxo-carcinoma of parotid.
No. 37. (No. 2390 Mic. Sect.) Cancer of liver (minute nodules).
No. 38. (No. 4037 Mic. Sect.) Cylindrical epithelioma of gall-duct.
No. 39. (Not catalogued.) Colloid cancer of stomach.
No. 40. (No. 2448 Mic. Sect.) Wall of an ovarian cyst, showing hair follicles, hair, &c.
No. 41. (No. 5555 Mic. Sect.) Ovarian tumor (cystic).
No. 42. (No. 3910 Mic. Sect.) Adenoma of mamma.
No. 43. (No. 4021 Mic. Sect.) Cysto-sarcoma of mamma. Other parts of the same tumor were carcinomatous.
No. 44. (No. 3490 Mic. Sect.) Carcinoma of mamma (cancer cylinders).
No. 45. (No. 5599 Mic. Sect.) Carcinoma of mamma (invasion of fat).
No. 46. (No. 1251 Mic. Sect.) Keloid growth from the breast of a negro.
No. 47. (No. 3872 Mic. Sect.) Keloid growth from ear.
No. 48. (No. 3885 Mic. Sect.) Condyloma from a negro. (See No. 22.)
No. 49. (No. 2222 Mic. Sect.) Melanotic tumor of leg.
No. 50. (No. 6128 Mic. Sect.) Melanotic tumor of back.
No. 51. (No. 3734 Mic. Sect.) Epithelioma of hand.
No. 52. (No. 5878 Mic. Sect.) Epithelioma of arm.
No. 53. (No. 5721 Mic. Sect.) Epithelioma of leg.
No. 54. (No. 6354 Mic. Sect.) Epithelioma of leg.
No. 55. (No. 6358 Mic. Sect.) Epithelioma of leg.
No. 56. (No. 6980 Mic. Sect.) Epithelioma of foot.
No. 57. (No. 5869 Mic. Sect.) Epithelioma of pudenda.
No. 58. (No. 6405 Mic. Sect.) Epithelioma of lip.
No. 59. (No. 3723 Mic. Sect.) Epithelioma of lip.
No. 60. (No. 3724 Mic. Sect.) Epithelioma of lip.
No. 61. (No. 5859 Mic. Sect.) Epithelioma of lip.
No. 62. (No. 7135 Mic. Sect.) Papillary growth of uvula.
No. 63. (No. 2270 Mic. Sect.) Epithelioma of larynx.
No. 64. (No. 2191 Mic. Sect.) Papillary growth of pharynx.
No. 65. (No. 4915 Mic. Sect.) Fatty liver,
No. 66. (No. 6530 Mic. Sect.) Fatty liver.
No. 67. (Not catalogued.) Fatty liver.
No. 68. (Not catalogued.) Nutmeg liver.
No. 69. (No. 4900 Mic. Sect.) Syphiloma of liver.
No. 70. (No. 3462 Mic. Sect.) Carcinoma of liver.
No. 71. (No. 3938 Mic. Sect.) Carcinoma of liver.
No. 72. (No. 3933 Mic. Sect.) Carcinoma of liver.
No. 73. (No. 6150 Mic. Sect.) Commencing carcinoma of liver. From a case of cancer of the stomach.

No. 74. (No. 2646 Mic. Sect.) Carcinoma of spleen.
No. 75. (No. 4293 Mic. Sect.) Carcinoma of pylorus.
No. 76. (No. 4502 Mic. Sect.) Carcinoma of pylorus.
No. 77. (No. 4506 Mic. Sect.) Carcinoma of pylorus.
No. 78. (No. 4717 Mic. Sect.) Carcinoma of pylorus.
No. 79. (No. 2454 Mic. Sect.) Carcinoma of ovary.
No. 80. (No. 2447 Mic. Sect.) Wall of an ovarian cyst.
No. 81. (Not catalogued.) Myoma of uterus.
No. 82. (Not catalogued.) Hepatized lung.
No. 83. (Not catalogued.) Apoplectic lung.
No. 84. (No. 3649 Mic. Sect.) Granular kidney.
No. 85. (No. 5640 Mic. Sect.) Mammary gland of bitch.
No. 86. (No. 4086 Mic. Sect.) Adenoma of mamma.
No. 87. (No. 4088 Mic. Sect.) Adenoma of mamma.
No. 88. (No. 6524 Mic. Sect.) Adenoma of mamma.
No. 89. (No. 4041 Mic. Sect.) Adenoma of mamma.
No. 90. (No. 4558 Mic. Sect.) Adenoma of mamma.
No. 91. (No. 4559 Mic. Sect.) Adenoma of mamma.
No. 92. (No. 6519 Mic. Sect.) Adenoma of mamma.
No. 93. (No. 5611 Mic. Sect.) Cysto-carcinoma of mamma; a part of the section shows the structure of cysto-sarcoma, a part of carcinoma.
No. 94. (No. 5612 Mic. Sect.) Another cut from the same growth as 5611 and 5614.
No. 95. (No. 5614 Mic. Sect.) Another cut from the same growth as 5611 and 5612.
No. 96. (No. 6555 Mic. Sect.) Adeno-carcinoma of mamma.
No. 97. (No. 2744 Mic. Sect.) Carcinoma of mamma.
No. 98. (No. 4316 Mic. Sect.) Carcinoma of mamma.
No. 99. (No. 4620 Mic. Sect.) Carcinoma of mamma.
No. 100. (No. 5689 Mic. Sect.) Carcinoma of mamma.
No. 101. (No. 6557 Mic. Sect.) Carcinoma of mamma.
No. 102. (Not catalogued.) Medullary carcinoma of mamma.
No. 103. (No. 5926 Mic. Sect.) Carcinoma of mamma (invasion of fat).
No. 104. (No. 5756 Mic. Sect.) Carcinoma of mamma (invasion of muscle).
No. 105. (No. 4698 Mic. Sect.) Melano-carcinoma of mamma.

This room contains also a few articles of hospital furniture,

No. 21. Four bedside chairs like those in Room 1.

No. 22. Nine window-shades like those in Room 1.

No. 23. Four rubber spittoons like those in Room 1.

No. 24. One clock like that in Room 1.

No. 25. One three-gallon water cooler like that in Room 1.

No. 26. Two revolving stools for the microscope case.

On the walls of this room are the following pictures:

No. 27. Portrait in oil of Dr. T. G. Morton, of Philadelphia, the celebrated craniologist. (From the Army Medical Museum.)

No. 28. Portrait in oil of Dr. P. S. Physic, of Philadelphia, the celebrated surgeon. (From the Army Medical Museum.)

No. 29. Photograph representing the stumps in fourteen cases of amputation for shot injury, at Army Square Hospital, Washington, D. C., in 1864.

No. 30. Frame containing nine daguerreotypes of microscopical subjects, made by Dr. J. W. Draper, of New York, in 1851–'52. (See remarks

below in connection with bound volumes of photomicrographs in Room No. 4.)

Eleven solar enlargements (to circles about 2 feet in diameter) from photomicrographs, made at the Army Medical Museum by Assistant Surgeon J. J. Woodward, U. S. A.

No. 31. Pleurosigma angulatum. Portion of frustule illuminated to show hexagons. Magnified 23,000 diameters.

No. 32. Coscinodiscus from Nottingham earth. Magnified 7,500 diameters.

No. 33. Artery and capillaries from lung of frog. Silver staining. Magnified 2,000 diameters.

No. 34. Striated muscle of mouse. Magnified 2,000 diameters.

No. 35. Section of ovary of cat, showing a Graafian follicle. Magnified 1,600 diameters.

No. 36. Blood corpuscles of dog. Photographed on a micrometer in one-thousandths of an inch.

No. 37. Human blood corpuscles. Photographed on a micrometer in one-thousandths of an inch. Magnified 4,350 diameters.

No. 38 A. Frustulia Saxonica, showing transverse striæ; magnified 8,400 diameters. B. Navicula Rhomboides from Bemis Lake, showing transverse striæ; magnified 8,400 diameters. C. The same as B, showing beads; magnified 8,400 diameters.

No. 39 A. Amphipleura Pellucida; magnified 3,500 diameters. B. The same; magnified 7,200 diameters. C. Amphipleura Sullivantii; magnified 3,500 diameters. D. The same; magnified 7,200 diameters.

No. 40. Pleurosigma angulatum. A. Frustule; magnified 2,560 diameters. B. Portion of the same; magnified 1,900 diameters.

No. 41. Pleurosigma angulatum. Portion of frustule illuminated to show beads; magnified 2,300 diameters.

The two lower panes of each window are occupied by photographic transparencies, on glass, from photomicrographs made at the Army Medical Museum by Assistant Surgeon J. J. Woodward. The circle occupied by the picture in each is about 10 inches in diameter, viz:

No. 42. (*a.*) Triceratium fembriatum, with four angles; magnified 1,000 diameters. (*b.*) Triceratium favus; magnified 1,000 diameters.

No. 43. (*a.*) Body scale of mosquito; magnified 3,100 diameters. (*b.*) Navicula lyra; magnified 1,650 diameters.

No. 44. (*a.*) Stinging apparatus of mosquito; magnified 200 diameters. (*b.*) Tail of mosquito; magnified 200 diameters.

No. 45. (*a.*) Mosquito; magnified 25 diameters. (*b.*) Head of mosquito; magnified 200 diameters.

No. 46. (*a.*) Heliopelta Lewenhoeckii; magnified 1,000 diameters. (*b.*) Surirella Gemma; magnified 3,200 diameters.

No. 47. (*a.*) First seven bands of Nobert's plate; magnified 1,450 diameters. (*b.*) Webb's test, The Lord's Prayer; magnified 1,450 diameters.

No. 48. (*a.*) Cancer of the liver, showing nucleated cylinders cut

across; magnified 800 diameters. (*b.*) Cancer of breast, showing branching nucleated cylinders; magnified 800 diameters.

No. 49. (*a.*) Cysto-carcinoma of female breast; magnified 440 diameters. (*b.*) Cysto-carcinoma of the female breast; magnified 140 diameters.

No. 50. (*a.*) Epithelial cancer of larynx, showing a papilla cut across; magnified 800 diameters. (*b.*) Cysto-carcinoma of the female breast; magnified 140 diameters.

No. 51. On the south wall of this room hangs a map of the United States, showing the geographical distribution of the post hospitals of the Army at the present time.

At the northwest corner of the ward is a small closet marked *b*, which contains the following articles:

1. One earth-closet commode, of walnut, Moule's patent. Manufactured by Earth Closet Company of Hartford, Conn.
2. Two delft urinals.
3. One delft bed-pan.
4. One metal bed-pan.
5. Two delft chambers.
6. Two inodorous china chambers, Army pattern.
7. One close-stool, Knight's patent.
8. Two oiled linen window shades.

Room No. 3.

This room is the dispensary of the post hospital. It is fitted up with shelves, counters, &c., in accordance with the plans issued by the Surgeon-General's Office to post hospitals for that purpose. These serve in the Exhibition to contain samples of the medicines issued by the purveyor's department in accordance with the standard Supply Table There are also two additional cases, containing hospital stores, dressings, chemicals, &c.

No. 1. The shelves of this case, and the drawers and closets beneath it and cases 2 and 3, contain samples of the medicines allowed by the Supply Table, in the original packages, viz:

MEDICINES.

I.—REGULAR SUPPLY.

[To be drawn semi-annually or annually for all posts.]

Articles.	Allowance for six months.					Allowance for three months.	
	Post of one company.	Post of two companies.	Post of four companies.	Post of six companies.	Post of one regiment.	General hospital of 250 beds.	500 men in the field.
MEDICINES.							
Acid:							
Acetic, in 4 oz. g. s. bottles ..... oz..	8	12	16	20	24	24	.....
Carbolic, for disinfection, in 1 lb. bottles, 95 per cent..... lb..	2	3	6	8	10	25	.....
Carbolic, pure, crystallized, in 4 oz. g. s. bottles..... oz..	4	4	8	12	16	48	4
Citric, in 8 oz. bottles..... oz..	16	16	16	32	32	96	8
Muriatic, in 8 oz. g. s. bottles..... oz..	8	8	8	16	16	16	.....
Nitric, in 4 oz. g. s. bottles ..... oz..	4	8	8	16	16	16	.....
Sulphuric, in 4 oz. g. s. bottles..... oz..	4	8	8	16	16	16	.....
Sulphuric, aromatic, in 8 oz. g. s. bottles..... oz..	8	16	16	16	16	96	8
Tannic, in 1 oz. bottles..... oz..	1	2	4	6	8	12	1
Tartaric, powdered, in 8 oz. bottles..... oz..	16	24	32	48	64	96	.....
Alcohol, in 32 oz. bottles..... bott..	12	12	24	36	48	96	2
Aloes, powdered, in 2 oz. bottles..... oz..	2	2	2	4	4	8	.....
Alumina and potassa, sulphate of (alum), in 4 oz. bottles..... oz..	8	16	16	16	24	48	.....
Ammonia:							
Aromatic spirits of, in 4 oz. g. s. bottles..... oz..	8	16	24	32	32	48	4
Carbonate of, in 8 oz. bottles ..... oz..	16	24	32	48	64	64	8
Muriate of, in 8 oz. bottles..... oz..	8	8	16	24	32	64	.....
Solution of, in 8 oz. g. s. bottles ..... oz..	24	48	64	96	96	192	16
Antimony and potassa, tartrate of (tartar emetic), in 1 oz. bot. oz..	1	1	1	2	2	4	1
Arsenic, pills of (1-20th of a gr. each), in g. s. bottles..... no..	100	100	100	200	200	800	200
Arsenite of potassa, solution of (Fowler's solution), in 4 oz. bot. oz..	4	4	8	8	12	24	4
Belladonna, alcholic extract of, in 1 oz. w. m. bottles..... oz..	1	1	1	2	2	4	1
Bismuth, subnitrate of, in 2 oz. bottles..... oz..	8	8	16	16	32	96	8
Borax, powdered, in 8 oz. bottles..... oz..	8	8	16	16	24	48	.....
Camphor, in 8 oz. bottles..... oz..	16	16	32	48	64	96	8
Castor oil, in 32 oz. bottles..... bott..	4	6	8	12	16	16	2
Cerate:							
Blistering, in 8 oz. tins..... oz..	8	16	32	40	48	64	4
Resin, in 1 lb. tins..... lb..	1	1	2	3	4	6	1
Simple, in 1 lb. tins..... lb..	4	4	8	12	16	32	2
Chalk, prepared, in 8 oz. bottles..... oz..	8	16	32	48	64	96	.....
Chloral, hydrate of, in 1 oz. g. s. bottles..... oz..	8	12	16	24	32	64	8
Chloroform, purified, in 8 oz. g. s. bottles..... oz..	24	32	64	96	96	224	64
Cinchona, fluid extract of (with aromatics), in 8 oz. bottles..... oz..	32	48	64	96	96	128	.....
Cinnamon, oil of, in 1 oz. g. s. bottles..... oz..	1	1	1	2	2	3	.....
Cod liver oil, in 1 pint bottles..... bott..	12	16	24	32	40	48	.....
Colchicum seed, fluid extract of, in 4 oz. bottles..... oz..	4	4	8	8	12	16	4
Colocynth, compound extract of, powdered, in 8 oz. bottles..... oz..	8	8	16	24	32	64	8
Copper, sulphate of, in 2 oz. bottles..... oz..	2	2	4	4	4	4	2
Croton oil, in 1 oz. g. s. bottles..... oz..	1	1	1	2	2	2	1
Digitalis, tincture of, in 2 oz. bottles..... oz..	2	2	4	6	6	12	.....
Ergot, fluid extract of, in 4 oz. g. s. bottles..... oz..	4	4	8	8	12	16	4
Ether:							
Compound spirits of (Hoffman's anodyne), in 8 oz g. s. bot. oz..	8	16	32	48	64	96	8
Stronger, for anæsthesia, in 1 lb. tins..... oz..	32	48	64	96	128	256	32
Spirit of, nitrous (sweet spirits of niter), in 8 oz. g. s. bot. oz..	24	32	64	64	96	96	8
Flaxseed, in tins ..... lb..	4	4	8	12	16	16	.....
Flaxseed meal, in tins..... lb..	8	12	16	24	32	64	.....
Ginger, fluid extract of in 8 oz. bottles ..... oz..	8	16	16	24	32	32	8
Glycerine, pure, in 8 oz. bottles ..... oz..	32	32	48	64	96	96	8
Gum arabic, powdered, in 8 oz. bottles..... oz..	8	16	24	32	40	96	8
Hyoscyamus, alcoholic extract of, in 1 oz. w. m. bottles..... oz..	1	1	2	2	3	8	.....
Iodine, in 1 oz. g. s. bottles..... oz..	2	3	4	6	7	8	1
Ipecacuanha, powdered, in 8 oz. bottles..... oz..	8	8	16	24	32	32	.....

Medicines—Continued.

I.—REGULAR SUPPLY—Continued.

Articles.	Allowance for six months.					Allowance for three months.	
	Post of one company.	Post of two companies.	Post of four companies.	Post of six companies.	Post of one regiment.	General hospital of 250 beds.	500 men in the field.
MEDICINES—Continued.							
Iron:							
Solution of the subsulphate of in 1 oz. bottles ..... oz..	2	2	2	3	4	6	2
Sulphate of, commercial, in 20 lb. wood boxes ..... lb..	20	40	60	80	100	120	.....
Tincture of the chloride of, in 8 oz. g. s. bottles ..... oz..	16	16	32	64	96	96	16
And quinia, citrate of, in 1 oz bottles ..... oz..	2	4	6	8	12	12	.....
Jalap, powdered, in 4 oz. bottles ..... oz..	4	4	8	8	8	8	.....
Lavender, compound spirits of, in 8 oz. bottles ..... oz..	16	24	32	58	64	64	.....
Lead, acetate of, in 8 oz. bottles ..... oz..	8	8	16	24	32	48	8
Liquorice, extract of, in paper ..... oz..	24	32	64	96	96	192	32
Liquorice root, powdered, in 8 oz. bottles ..... oz..	8	8	8	16	24	64	8
Magnesia:							
Heavy calcined, in 4 oz. bottles ..... oz..	4	8	16	20	24	24	.....
Sulphate of, in 8 lb. tins ..... lb..	8	16	24	32	48	64	8
Mercurial ointment, in 1 lb. pots ..... lb..	1	1	2	3	4	6	1
Mercury:							
Corrosive chloride of (corrosive sublimate), in 1 oz. bottles ..... oz..	1	1	2	3	4	4	1
With chalk, in 2 oz. bottles ..... oz..	2	2	4	6	8	6	.....
Mild chloride of (calomel) in 2 oz. bottles ..... oz..	2	2	4	4	6	6	2
Ointment of the nitrate of (citrine ointment), in 4 oz. pots .. oz..	4	4	8	12	16	16	.....
Pill of (blue mass), in 8 oz. pots ..... oz..	8	8	16	24	32	32	8
Red oxide of, in 1 oz. bottles ..... oz..	1	1	2	3	4	4	.....
Morphia, sulphate of, in ¼ oz. bottles ..... oz..	½	½	1	1½	2	2	½
Mustard seed, black, ground, in 6 lb. tins ..... lb..	6	6	12	18	24	36	6
Nux vomica, alcoholic extract of, powdered, in 1 oz. bottles .... oz..	1	1	1	1	1	4	.....
Olive oil, in 1 pint bottles ..... bott..	6	8	12	16	20	24	.....
Opium:							
Camphorated tincture of, in 8 oz. bottles ..... oz..	16	24	48	64	96	96	24
Compound powder of (Dover's Powder), in 8 oz. bottles .... oz..	8	16	32	48	64	64	8
Deodorized tincture of, in 4 oz. bottles ..... oz..	4	4	8	12	16	24	.....
Powdered, in 8 oz. bottles ..... oz..	8	8	16	24	32	32	8
Tincture of (laudanum), in 8 oz. bottles ..... oz..	16	24	32	48	64	96	16
Pepper, cayenne ground, in 8 oz. bottles ..... oz..	4	4	8	12	16	32	8
Peppermint, spirit of, in 4 oz. bottles ..... oz..	8	16	24	32	32	32	8
Pills:							
Camphor (grains two) and opium (grain one) in bottles .... no..	.....	.....	.....	.....	.....	.....	200
Compound cathartic, in bottles ..... no..	100	200	300	400	500	600	100
Opium in bottles ..... no ..	.....	.....	.....	.....	.....	.....	200
Podophyllum, resin of, in 1 oz. bottles ..... oz..	1	1	2	2	3	4	1
Potassa:							
Caustic, in 1 oz. g. s. bottles ..... oz..	1	1	1	1	1	1	.....
Acetate of, in 8 oz. bottles ..... oz..	16	16	16	24	24	48	.....
Bicarbonate of, in 8 oz. bottles ..... oz ..	16	16	24	32	32	32	8
Bitartrate of, powdered (cream of tartar), in 8 oz. bottles.. oz..	16	16	32	32	48	64	16
Chlorate of, powdered, in 8 oz. bottles ..... oz..	16	16	24	32	48	96	8
Nitrate of, powdered, in 8 oz. bottles ..... oz..	8	8	16	16	24	48	.....
Permanganate of, in 1 oz. bottles ..... oz..	2	2	4	6	8	10	2
Potassium, bromide of, in 4 oz. bottles ..... oz..	8	8	16	32	40	64	8
Potassium, iodide of, in 8 oz. bottles ..... oz .	16	24	48	96	112	112	8
Quinia, sulphate of, in 1 oz. bottles, or compressed in tins ..... oz..	10	15	25	30	40	60	10
Rhubarb, powdered, in 4 oz. bottles ..... oz..	4	4	8	12	16	24	.....
Rochelle salt, powdered, in 8 oz. bottles ..... oz..	32	48	64	80	69	96	16
Santonin, in 1 oz. bottles ..... oz..	1	1	1	1	2	2	.....
Seneka, fluid extract of, in 8 oz. bottles ..... oz..	8	16	24	32	48	64	8
Silver, nitrate of:							
In crystals, in 1 oz. g. s. bottles ..... oz..	1	1	1	2	2	4	1
Fused, in 1 oz. g. s. bottles ..... oz..	1	1	2	2	3	4	1
Soap:							
Castile, in paper ..... lb..	4	6	8	12	16	24	8
Common, in bars ..... lb..	10	15	20	25	25	.....	.....
Soda:							
Bicarbonate of, in 8 oz. bottles ..... oz..	24	32	48	64	64	96	16
Chlorinated solution of, in 1 lb. g. s. bottles. ..... lb..	4	6	8	12	16	20	1

Medicines—Continued.

I.—REGULAR SUPPLY—Continued.

Articles.	Allowance for six months.					Allowance for three months.	
	Post of one company.	Post of two companies.	Post of four companies.	Post of six companies.	Post of one regiment.	General hospital of 250 beds.	500 men in the field.
MEDICINES—Continued.							
Squill:							
Powdered, in 1 oz. bottles ..... oz..	1	2	3	4	5	6	.....
Sirup of, in 1 lb. bottles ..... lb..	4	8	12	16	24	20	4
Strychnia, in ½ oz. bottles ..... oz..	½	½	½	½	½	½	.....
Sulphur, washed in 8 oz. bottles ..... oz..	16	16	32	32	48	64	16
Turpentine, oil of, in 32 oz. bottles ..... bott..	2	4	6	8	10	12	1
Vaccine virus, quantities as required (see note).							
Wax, white, in paper ..... oz..	4	4	8	12	16	32	1
Zinc:							
Acetate of, in 2 oz. bottles ..... oz..	2	2	2	4	4	6	.....
Oxide of, in 1 oz. bottles ..... oz..	2	2	2	2	2	4	.....
Solution of chloride of, in 1 lb. g. s. bottles ..... lb..	2	4	6	8	10	12	.....
Sulphate of, in 1 oz. bottles ..... oz..	2	2	3	4	5	6	1

NOTE.—Vaccine virus is to be procured by application to medical directors of departments. Medical directors will obtain it by requisition upon the Surgeon-General.

II.—SUPPLEMENTARY LIST OF MEDICINES.

[To be obtained on special requisition only.]

Acid:							
Arsenious, in ½ oz. g. s. bottles ..... oz..	½	½	½	1	1	1	.....
Benzoic, in 1 oz. g. s. bottles ..... oz..	1	1	1	2	2	2	.....
Chromic, in 1 oz. g. s. bottles ..... oz..	1	1	1	1	1	1	.....
Gallic, in 1 oz. bottles ..... oz..	1	1	1	1	1	1	.....
Phosphoric, diluted, in 4 oz. g. s. bottles ..... oz..	4	4	4	4	4	.....	.....
Hydrocyanic, diluted, in 1 oz. g. s. bottles ..... oz..	1	1	1	1	1	1	.....
Aconite root:							
Fluid extract of, in 8 oz. bottles ..... oz..	8	8	16	24	24	32	8
Tincture of, in 2 oz. bottles ..... oz..	2	2	2	2	2	2	.....
Ammonia, phosphate of, in 2 oz. g. s. bottles ..... oz..	2	2	2	2	2	2	.....
Anise, oil of, in 1 oz. g. s. bottles ..... oz..	1	1	2	2	3	4	.....
Arnica, fluid extract of, in 4 oz. bottles ..... oz..	4	4	8	8	16	24	.....
Arsenic and mercury, solution of the iodide of, in 1 oz. g. s. bottles ..... oz..	1	1	1	1	1	1	.....
Asafetida, in 4 oz. bottles ..... oz..	4	4	4	4	4	8	.....
Atropia, sulphate of, in ½ oz. g. s. bottles ..... oz..	⅛	⅛	⅛	⅛	⅛	⅛	.....
Bismuth:							
Subcarbonate of, in 4 oz. bottles ..... oz..	4	4	4	8	8	16	.....
Tannate of, in 1 oz. bottles ..... oz..	1	1	1	2	2	4	.....
Blistering liquid, in 4 oz. g. s. bottles ..... oz..	4	4	4	8	8	8	4
Bromine, in 1 oz. g. s. bottles ..... oz..	1	1	1	1	1	1	.....
Buchu, fluid extract of, in 8 oz. g. s. bottles ..... oz..	16	16	32	48	64	64	.....
Cacao, butter of, in 4 oz. tins ..... oz..	4	4	8	12	16	20	.....
Calabar bean, extract of, in ½ oz. bottles ..... oz..	⅛	⅛	⅛	⅛	⅛	⅛	⅛
Cantharides:							
Tincture of, in 1 oz. bottles ..... oz..	1	1	1	1	1	1	.....
Cerate of the extract of, in 4 oz. pots ..... oz..	4	4	4	4	4	8	.....
Catechu, in 4 oz. bottles ..... oz..	4	4	8	8	8	16	.....
Chamomile flowers, in paper ..... lb..	1	1	1	1	1	1	.....
Cinchona bark, powdered, in 8 oz. bottles ..... oz..	8	8	16	24	32	64	.....
Cloves, oil of, in 1 oz. bottles ..... oz..	1	1	1	1	1	1	.....
Collodion, in 1 oz. g. s. bottles ..... oz..	1	2	4	4	4	4	1
Copaiba, in 1 lb. bottles ..... oz..	32	32	64	96	128	128	.....
Creasote, in 1 oz. g. s. bottles ..... oz..	1	1	1	1	1	1	.....
Cubeb, oleo-resin of, in 8 oz. bottles ..... oz..	8	8	8	16	16	32	.....
Gentian, fluid extract of, in 8 oz. bottles ..... oz..	16	24	32	48	48	64	.....

Medicines—Continued.

II.—SUPPLEMENTARY LIST OF MEDICINES Continued.

Articles.	Allowance for six months.					Allowance for three months.	
	Post of one company.	Post of two companies.	Post of four companies.	Post of six companies.	Post of one regiment.	General hospital of 250 beds.	500 men in the field.
Gum arabic, in 4 oz. bottles ..... oz..	4	4	8	12	16	96	.....
Guaiac, resin of, in 8 oz. bottles ..... oz..	8	8	16	24	24	64	.....
Indian hemp, purified extract of, in 1 oz. pots ..... oz..	1	1	2	2	3	3	.....
Ipecacuanha, fluid extract of, in 8 oz. bottles ..... oz..	8	8	8	16	24	32	8
Iron:							
Dried sulphate of, in 4 oz. bottles .. .. oz..	4	4	4	8	8	16	.....
By hydrogen, in 1 oz. bottles ..... oz..	1	1	1	2	2	3	.....
Hypophosphite of, in 2 oz. bottles ..... oz..	2	2	2	4	4	6	.....
Sirup of the iodide of, in 8 oz. g. s. bottles ..... oz..	8	8	16	24	32	32	.....
Oxalate of, in 2 oz. bottles ..... oz..	2	2	2	4	4	6	.....
And potassa, tartrate of, in 1 oz. bottles ..... oz..	2	2	2	4	4	6	.....
Pyrophosphate of, in 4 oz. bottles ..... oz..	4	4	8	12	16	24	.....
Mercury:							
Green iodide of, in 1 oz. g. s. bottles ..... oz..	1	1	2	3	4	4	.....
Yellow subsulphate of (turpeth mineral), in 1 oz. bottles .. oz..	1	1	1	1	1	1	.....
Morphia, acetate of, in ¼ oz. bottles ..... oz..	¼	¼	¼	¼	¼	¼	.....
Myrrh, in 4 oz. bottles ..... oz..	4	4	8	8	16	16	.....
Origanum, oil of, in 1 oz. g. s. bottles ..... oz.	1	1	1	1	1	1	.....
Potassium, cyanide of, in ⅛ oz. bottles .. .. oz..	⅛	⅛	⅛	⅛	¼	¼	.....
Sarsaparilla, fluid extract of, in 8 oz. bottles ..... oz..	16	24	32	48	64	64	.....
Senna, confection of, in 1 lb. jars ..... lb..	1	1	1	2	2	2	.....
Sinapism paper ..... packs..	1	1	1	1	1	1	.....
Soda:							
Phosphate of, exsiccated, in 4 oz. bottles ..... oz..	8	8	8	8	8	16	.....
Sulphite of, exsiccated, in 4 oz. bottles ..... oz..	8	8	16	24	32	48	8
Sulphur, in roll ..... lb..	6	6	6	6	6	6	.....
Tar, wood, in 8 oz. w. m. bottles ..... oz..	8	16	24	32	48	48	.....
Taraxacum, fluid extract of, in 8 oz. bottles ..... oz..	8	8	8	8	8	16	.....
Tolu, balsam of, in 8 oz. bottles ..... oz..	8	8	8	8	8	8	.....
Valerian, fluid extract of, in 8 oz. bottles ..... oz..	8	8	16	24	32	32	.....
Veratrum viride:							
Fluid extract of, in 1 oz. bottles ..... oz..	1	1	1	1	2	2	.....
Tincture of, in 2 oz. bottles ..... oz..	2	2	2	2	2	6	.....
Wax, yellow, in paper ..... oz..	8	8	12	16	16	16	.....
Wild-cherry bark, fluid extract of, in 8 oz. bottles ..... oz..	16	16	32	48	64	64	.....

Nos. 2 and 3. The shelves of these cases contain a full set of dispensing bottles and jars, such as are issued to the larger post hospitals on special requisition. These contain samples of medicines on the foregoing list open for inspection.

No. 4. Apothecaries' scales and weights of the standard pattern. This is a small and accurate balance made by Becker & Sons, of New York, with two sets of weights, viz, an apothecaries' set ¼ grain to 1 ounce, and a metric set 1 milligram to 20 grams.

No. 5. A case, with glass doors, containing (*a*) samples of the hospital stores authorized by the Standard Supply Table, viz:

HOSPITAL STORES.

Articles.	Allowance for six months.					Allowance for three months.	
	Post of one company.	Post of two companies.	Post of four companies.	Post of six companies.	Post of one regiment.	General hospital of 250 beds.	500 men in the field.
HOSPITAL STORES.							
Arrow-root, in tins ..... lb..	5	5	10	15	20	25	.....
Barley, in tins ..... lb..	5	10	15	20	25	30	.....
Beef, extract of, Liebig's, in porcelain jars ..... lb..	6	10	15	20	25	30	16
Brandy, in 32 oz. bottles ..... bott..	12	16	24	32	36	48	12
Candles:							4
Sperm or composition, half length, in boxes ..... lb..							
Wax, for night operations ..... lb..	1	1	1	2	2	.....	.....
Cinnamon, ground, in 4 oz. bottles ..... oz..	4	8	12	16	20	24	.....
Cocoa or choc late, in tins or cakes ..... lb..	2	4	6	8	10	12	.....
Corn starch, in tins ..... lb..	2	4	6	8	10	12	.....
Farina, in tins ..... lb..	2	4	6	8	10	12	4
Gelatine, shred, in 4 oz. packages ..... oz..	4	8	16	24	24	32	.....
Ginger, ground, in 8 oz. bottles ..... oz..	8	8	16	16	24	32	.....
Milk, concentrated, in 1 lb. tins ..... lb..	12	18	.....	.....	.....	.....	16
Nutmegs, in 2 oz. bottles ..... oz..	2	2	4	6	8	8	2
Pepper, black, ground, in 4 oz. bottles ..... oz..	8	12	16	24	32	48	8
Sugar, white, crushed, in boxes or tins ..... lb..	12	18	24	48	64	120	12
Tapioca, in tins ..... lb ..	2	4	6	8	10	12	.....
Tea, black, in tins or original chests ..... lb..	10	15	25	40	60	100	5
Whisky, in 32 oz. bottles ..... bott..	12	24	36	48	72	120	24
Wine, in 22 oz. bottles ..... bott..	12	24	24	36	48	60	.....

(*b.*) Samples of the bandages, splints, and dressings authorized by the Supply Table, viz:

DRESSINGS.

Articles.	Allowance for six months.					Allowance for three months.	
	Post of one company.	Post of two companies.	Post of four companies.	Post of six companies.	Post of one regiment.	General hospital of 250 beds.	500 men in the field.
Bandages, roller, unbleached and unsized, assorted, in a pasteboard box—1 dozen, 1 inch by 1 yard; 2 dozen, 2 inches by 3 yards; 2 dozen, 2½ inches by 3 yards; 1 dozen, 3 inches by 4 yards; ½ dozen, 3½ inches by 5 yards; 1 dozen, 4 inches by 6 yards; ½ dozen, 4 inches by 8 yards ..... doz..	12	18	24	32	48	96	32
Bandages, suspensory ..... no..	2	4	6	8	8	10	4
Binder's boards:							
2½ by 12 inches ..... pieces..	12	18	24	36	48	48	12
4 by 17 inches ..... pieces..	12	18	24	36	48	48	12
Cotton bats ..... no..	2	3	4	6	8	10	2
Cotton wadding ..... sheets..	4	4	4	6	8	10	2
Flannel, red, all wool ..... yds..	4	6	8	10	12	20	4
Gutta percha cloth ..... yds..	2	4	6	8	8	12	2
Lint:							
Patent ..... lb..	2	4	6	8	10	12	4
Picked ..... lb..	1	2	3	4	4	10	2
Muslin, unbleached, unsized, 1 yard wide ..... yds..	8	10	16	20	25	40	10

Dressings—Continued.

Articles.	Allowance for six months.					Allowance for three months.	
	Post of one company.	Post of two companies.	Post of four companies.	Post of six companies.	Post of one regiment.	General hospital of 250 beds.	500 men in the field.
Needles:							
Cotton, thimble, in case ..... no.	.....	.....	.....	.....	.....	.....	1
Assorted ..... papers.	1	1	1	1	1	1	.....
Upholsterer's ..... no.	2	2	2	2	2	2	.....
Oakum, fine, picked ..... lb.	10	15	20	30	40	60	5
Oiled muslin, in 2 yard pieces ..... yds.	4	4	6	8	10	20	4
Oiled silk, in 2 yard pieces ..... yds.	2	2	4	6	8	10	2
Plaster of Paris, in 5 lb. tins ..... lb.	5	5	10	10	15	25	.....
Pencils, hair (assorted sizes), in vials ..... no.	6	12	18	24	26	36	6
Pins ..... papers.	2	3	5	8	10	20	3
Plaster:							
Adhesive, 5 yards in a can ..... yds.	10	15	20	30	40	60	5
Isinglass, 1 yard in a case ..... yds.	4	6	8	12	16	20	10
Silk, gray, for shades ..... yds.	½	½	1	1	1	2	½
Silk ligature ..... oz.	½	½	1	1½	2	3	½
Splints ..... sets.	1	1	1	2	2	3	1
Splints, Smith's anterior ..... no.	2	3	3	4	4	6	3
Splints, material for making, felt ..... pieces.	2	4	6	8	8	12	2
Sponge, fine, small pieces ..... oz.	6	10	16	20	24	30	10
Tape, cotton, or twilled stay binding ..... pieces.	2	3	6	8	10	15	3
Thread:							
Linen, unbleached ..... oz.	1	2	3	4	5	12	1
Cotton, spools, assorted ..... no.	2	2	2	4	4	12	.....
Tow ..... lb.	2	4	8	12	16	20	10
Towels ..... doz.	2	4	6	8	10	12	2
Towels, roller ..... doz.	½	1	1½	2	2½	3	.....
Twine, ½ coarse ..... oz.	8	16	24	32	48	48	8

No. 6. A case with glass doors, containing samples of the chemicals and chemical apparatus authorized by the Supply Table. These articles, or a part of them, are issued to medical officers upon special requisition when approved by the Surgeon-General. Such requisition should set forth the special purpose for which the articles are desired, and will be forwarded to the Surgeon-General through the medical director for approval.

This list is substituted for the "test chest," which has been dropped from the Standard Supply Table. Sutton's Volumetric Analysis will be furnished for use in connection with the articles on this list:

SOLID CHEMICALS IN TWO OZ. GLASS STOPPERED JARS.

Acids:
- Arsenious.
- Chromic.
- Oxalic.
- Tartaric.

Ammonium:
- Carbonate of.
- Chloride of.
- Molybdate of.
- Oxalate of.

Brazil wood, piece of.

Barium:
- Carbonate of.
- Chloride of.
- Hydrate of.
- Nitrate of.

Calcium:
- Carbonate of.
- Chloride of.
- Sulphate of.

Cobalt, nitrate of.
Copper:
- Foil.
- Oxide of.
- Sulphate of.

Iron:
- Wire.
- Chloride of.
- Sulphate of.
- Sulphuret of.

Lead, acetate of.
Magnesium, sulphate of.
Magnesite in fragments.
Manganese, oxide of.
Mercury:
- Chloride of.
- Oxide of.
- Nitrate of.

Platinum, chloride of.
Potassium:
- Bichromate of.
- Carbonate of.
- Cyanide of.
- Ferricyanide of.
- Ferrocyanide of.
- Hydrate of.
- Nitrate of.
- Permanganate of.
- Sulphate of.
- Sulphocyanide of.

Sodium:
- Acetate of.
- Carbonate of.
- Chloride of.
- Biborate of—pure, dry.
- Hydrate of.
- Hyposulphite of.
- Sulphate of.
- Sulphite of.
- Phosphate of.
- Ammoniacal phosphate of.

Tin, chloride of.
Uranium, nitrate of.
Urea.
Zinc.

LIQUID CHEMICALS IN FOUR OZ. GLASS STOPPERED VIALS.

Acid:
- Acetic.
- Hydrochloric.
- Nitric.
- Sulphuric.

Alcohol, absolute.
Ammonia, solution of.
Benzol.
Glycerine.
Antimoniate of potassium, solution of.

APPARATUS.

Balance, in case*	no.	1
Beakers:		
In nest	nest	1
2, 4 and 6 oz	no.	6
Blowpipe, with forceps and reagents	no.	1
Burner (Bunsen's)	no.	1
Bottles:		
g. s., n. m., 1, 2 and 4 oz	no.	18
g. s., w. m., ½, 1 and 2 oz	no.	18
Capsules:		
(Porcelain), nests of six	nest	1
4 oz	doz.	½
8 oz	no.	3
Casserol, with cover	no.	1
Corks:		
Assorted	doz.	3
India-rubber, perforated	doz.	1
Cork borers (set of six)	set.	1
Cork tongs	no.	1
Crucibles:		
(Porcelain), conical	no.	4
Hessian	nest.	1
Crucible tongs	no.	1
Drying apparatus, sulphuric acid	no.	1
Files, set of six	set.	1
Flasks:		
Flat-bottomed, with lip	no.	6
Schuster's, plain or stoppered	no.	6
Round-buttoned, long necked	no.	2
Funnels, glass	no.	2
Funnel tubes	no.	2
Filters, cut, white (in packs of 100)	packs.	3
Filtering paper, German or Swedish	quire.	1
Forceps for handling small objects	no.	1
Mortar and pestle (porcelain)	no.	1

*This balance is the same as that referred to above—and therefore will not be required if already at the post.

MEASURING APPARATUS.

Graduated cylinder:		
200 cc	no.	1
100 cc., stoppered	no.	1
50 cc	no.	1
25 cc	no.	1
Flask:		
500 cc	no.	1
100 cc	no.	1
Burette:		
50 cc	no.	1
25 cc	no.	2
Pipette:		
50 cc	no.	1
25 cc	no.	1
10 cc	no.	2
20 cc., graduated	no.	1
5 cc., graduated	no.	2
2 cc., graduated	no.	2
Platinum:		
Foil	square inches.	2
Wire	feet.	3
Capsule, 3 in	no.	1
Crucible, 1 oz	no.	1
Retorts, 8 oz., 32 oz	no.	2
Rods, glass	doz.	1
Scoop, horn	no.	1
Spatulas, steel	no.	2
Spirit lamp, simple	no.	1
Spirit lamp, Argand	no.	1
Specific gravity bottle	no.	1
Specific gravity bulbs	no.	2
Sulphureted hydrogen apparatus	no.	1
Still, copper, half gallon capacity	no.	1
Stop-cocks for rubber tubing	no.	2
Test tubes:		
Nests of six	nests.	2
Assorted	doz.	1
Test-tube brushes	no.	2
Test-tube stand	no.	1
Test glasses, on foot	doz.	½
Tubing, glass	lbs.	3
Tubing, rubber	feet.	12
Block-tin pipe, ½ inch, for condensing distilled water	feet.	20
Tubes:		
Chloride of calcium	no.	3
U	no.	6
Thermometer	no.	1
Watch glasses, pairs	no.	3
Watch-glass holder	no.	1
Woulff's bottles, 3 oz	no.	2
Wash bottle	no.	1
Water bath for drying	no.	1
Evaporating dishes, iron, porcelain lined, 1 and 2 pints	no.	3
Geissler's potash bulbs	set.	1

This room contains also the following articles of hospital furniture:

No. 7. One clock like those in Rooms 1 and 2.

No. 8. Two window shades.

On the walls of this room are the following pictures:

No. 9. Photograph of Surgeon Thomas G. Mower, surgeon's mate, December 2, 1812, president of Army Medical Board. Born February 18, 1790. Died December 7, 1853.

No. 10. Photograph of Surgeon Charles S. Tripler, medical director, Army of the Potomac. Born January 19, 1808. Died October 20, 1866.

No. 11. Photograph of Surgeon R. S. Satterlee, brigadier-general and medical purveyor, United States Army.

No. 12. Photograph of Assistant Surgeon W. J. H. White, assistant surgeon, March 12, 1856; medical director Sixth Army Corps. Killed in action at Antietam, September 17, 1862.

The lower panes of the windows are occupied by glass transparencies about 10 inches in diameter. From photomicrographs made by Assistant Surgeon J. J. Woodward, United States Army, at the Army Medical Museum.

No. 13. (*a.*) Parasite of soldier beetle; magnified 45 diameters. (*b.*) Head of cysticercus; 150 diameters.

No. 14. (*a.*) Longitudinal section of pine wood; 340 diameters. (*b.*) Transverse section of sugar-cane; 100 diameters.

Room No. 4.

This room is the office or "surgery" of the post hospital. It has been fitted up with cases to contain samples of the surgical instruments and appliances, meteorological instruments and microscope, blank forms, medical books, &c., issued to post hospitals. It also contains copies of the various publications of the Surgeon-General's Office.

SURGICAL INSTRUMENTS.

Case No. 1 contains surgical instruments, viz:

No. 1. Personal set of surgical instruments, made by D. W. Klobe, of Philadelphia.

No. 2. Personal set of surgical instruments, made by J. M. Gemrig, of Philadelphia.

No. 3. Personal set of surgical instruments, made by G. Tiemann & Co., of New York.

These are samples of the personal sets authorized by the Supply Table. A set of these instruments is issued to each medical officer for his own personal use, under the following regulations:

The transfer of surgical instruments issued to medical officers *for their personal use* is positively forbidden, unless authorized by the Surgeon-General. Each medical officer shall retain those instruments in his *immediate* possession so long as he remains in the Army, and will be held responsible for their complete and serviceable condition, and *for their easy accessibility at all times.* If the instruments be lost, destroyed, or damaged, they must be replaced or repaired as soon as possible by means of a requisition upon the Surgeon-General, setting forth fully the causes of such losses or damage. If the loss or damage result from the unavoidable casualties of the service, the expense of replacing or repairing the instruments will be paid by the Medical Department; if from any other causes, such expenses must be paid by the medical officer.

The following is a list of the instruments:

CASE FOR CAPITAL OPERATIONS.

Two amputating-knives, one long, one medium.
Two catlings, one long, one medium.
One cartilage-knife.
One bistoury, straight.
Three scalpels.
One capital saw, long, bow, two blades.
One chain-saw.
One metacarpal-saw.
One Hey's saw.
One trephine, conical.
One trephine, small crown.
One razor, small.
One raspatory.
One elevator.
One brush.
One bone-forceps, Liston's, long, sharp, spring-handle.
One bone-forceps, broad-edged, slightly curved, spring-handle.
One bone forceps, gnawing, spring-handle.
One bone-forceps, sequestrum, spring-handle.
One lithotomy-forceps.

One artery-forceps.
One artery-needle.
One artery-needle key.
Twelve surgeon's needles.
Six wire suture-needles.
One tourniquet, screw, with pad.
One tenaculum.
One scissors.
One chisel.
One gouge.
One trocar and canula, straight.
Four drills (with one handle).
Two retractors.
Twelve yards suture-wire, silver.
One-fourth ounce ligature-silk.
One-eight ounce wax.
One mahogany case, brass bound, slide-catch.
One leather pouch.

CASE FOR MINOR OPERATIONS.

One amputating-knife.
One finger-knife.
One hernia-knife.
Three bistouries, one straight, one curved, one curved—probe pointed.
Two scalpels.
One artery-forceps.
One ball-forceps.
One dressing-forceps.
One dissection-forceps.
One œsophageal forceps.
One Trousseau's tracheotomy forceps.
One artery-needle.
One artery-needle key.
Twelve surgeon's needles.
Six wire suture-needles.
Three scissors, one straight, one angular, one curved.
One tenaculum.
One trocar and canula, curved.
One Belloc's canula.
Two tracheotomy tubes (double).
One tonsillotome.
One œsophageal probang.
One Nelaton's probe.
One director.
One cutting-pliers, small.
One wire ecraseur.
Two grooved staffs, medium and large.
One Syme's staff.
One sound, small, straight.
Six steel bougies, silvered, double curve, Nos. 1 and 2, 3 and 4, 5 and 6, 7 and 8, 9 and 10, 11 and 12.
Three G. E. bougies, olive-pointed.
Three silver catheters, Nos. 3, 6, and 9.
Six elastic catheters, Nos. 1, 3, 5, 7, 9, and 11.
One prostate catheter, silver.
Twenty-four suture-pins, silvered.
Six yards suture-wire, silver.
One-quarter ounce ligature-silk.
One-eighth ounce wax.
Six serre-fines.
Three gutta percha bougies, olive points.
One Sayre's probe, silver.
One brush-holder (silver) for larynx.
One Politzer's air-bag.
One powder-blower for larynx.
One mahogany case, brass bound, slide-catch.
One leather pouch.

CASE FOR THE EYE AND EAR.

One Anel's syringe.
One set Bowman's probes and dilators, silver.
Two styles, silver.
One cataract-knife, Beer's.
Two cataract-needles, one lance-headed.
One broad needle.
One curette.
One cystotome.
One Tyrrell's hook.
One Critchett's spoon.
One speculum, Laurence's.
One iris knife.
One pair of iris scissors.
Two pairs iris forceps, one straight, one curved.
One eustachian catheter.
One set ear specula, Wilde's or Toynbee's.
One ophthalmoscope.
Two laryngeal mirrors, one square, one elliptical, with reflector.
One yard silver suture-wire, fine.
One pair cilia forceps.
One sharp hook.
One strabismus hook.
One pair scissors, straight.
One pair scissors, curved on the flat.
One pair scissors, strabismus.

Six needles, fine.
One-eighth ounce silk, fine.
One scoop and hook, for removing foreign bodies from the eye and ear.
One pair forceps, angular, for removing foreign bodies from the ear, Wilde's.
One set test-types, Snellen's.
One scruple of sulphate of atropia (in g. s. bottle).
Two scruples of alcoholic extract of calabar bean (in g. s. bottle).
One sheet calabarized gelatine.
One Dix's spud.
One lens-scoop.
One lid-holder, large.
One lid-holder, small.
One spatula, rubber.
One iridectomy forceps.
One fixation forceps.
One iridectomy knife, angular.
One Graefe's knife, concave.
One Graefe's -speculum.
One strabismus hook.
One pair iris scissors.
One Thomson's optometer.
One mahogany case, brass bound, slide-catch.
One leather pouch.

THE POCKET-CASE.

One scalpel.
Three bistouries, one straight, one curved, one curved, probe-pointed.
One tenotome.
One thumb-lancet.
One artery-forceps.
One dissection-forceps.
One dressing-forceps.
One artery-needle.
Six surgeon's needles.
Three wire suture-needles.
One exploring needle.
One tenaculum.
One scissors.
One director.
One probe.
One Nelaton's probe.
One caustic-holder,
One silver catheter, compound.
Six yards suture-wire, silver.
One-fourth ounce ligature-silk.
One-eighth ounce wax.
One Russia leather case.

FOR LOCAL ANÆSTHESIA, DIAGNOSIS, ETC.

One nebulizer (Richardson's), with two tubes, one single, one double.
One medical thermometer.
One urinometer.
Litmus paper—Red, six sheets; blue, six sheets.
One hypodermic syringe, 3 points.
One mahogany case, brass bound, slide-catch.
One leather pouch.

SURGICAL INSTRUMENTS ISSUED TO POST HOSPITALS IN ACCORDANCE WITH THE STANDARD SUPPLY TABLE.

No. 4.—FIELD CASE.

Two amputating-knives, one long, one medium.
Two catlings, one long, one medium.
Two scalpels.
Three bistouries, one straight, one curved, one curved, probe-pointed.
One hernia-knife.
One finger-knife.
One capital saw, long, bow, two blades.
One chain-saw.
One metacarpal-saw.
One Hey's sa...
One trephine, conical.
One razor, small.
One raspatory.
One elevator.
One brush.
One bone forceps, broad-edged, slightly curved, spring handle.
One bone forceps, sequestrum, spring handle.
One artery-forceps.

One ball-forceps.
One dressing-forceps.
One dissection forceps.
One artery needle.
One artery-needle key.
Twelve surgeon's needles.
Six wire-suture needles.
One tourniquet, screw, with pad.
One tenaculum.
Two scissors, one straight, one angular.
Two retractors.
One trocar and canula, curved.
One Nelaton's probe.
One director.
Six steel bougies, silvered, double curve, Nos. 1 and 2, 3 and 4, 5 and 6, 7 and 8, 9 and 10, 11 and 12.
Three silver catheters, Nos. 3, 6, and 9.
Six elastic catheters, Nos. 1, 3, 5, 7, 9, and 11.
Six yards suture wire, silver.
Four ounces ligature silk.
One-half ounce wax.
One mahogany case, brass-bound, slide-catch.
One leather pouch.

No. 5.—POCKET CASE.

One scalpel.
Three bistouries, one straight, one curved, one curved, probe-pointed.
One tenotome.
Six surgeon's needles.
Three wire suture-needles.
One exploring needle.
One tenaculum.
One scissors.
One director.
One probe.
One thumb-lancet.
One artery-forceps.
One dressing-forceps.
One artery-needle.
One Nelaton's probe.
One caustic-holder.
One silver catheter, compound.
Six yards suture-wire, silver.
One-quarter ounce ligature-silk.
One-eighth ounce wax.
One Russia leather case.

No. 6.—POST-MORTEM CASE.

One cartilage knife.
Three scalpels.
One tenaculum.
One dissection forceps.
One chain and hooks.
Two needles and thread.
One saw.
One enterotome.
One scissors.
One blow-pipe.
One chisel.
Mahogany box.

No. 7.—TOOTH-EXTRACTING CASE.

One forceps, for extracting upper front root.
One forceps, for upper and lower back root.
One forceps, for upper wisdom, either side.
One forceps, for upper bicuspid and canine, either side.
One forceps, for upper incisor and canine.
One forceps, for lower incisor and bicuspid, either side.
One forceps, for lower molar, either side.
One forceps, for right and left upper molar.
One forceps, for lower bicuspid and canine.
One forceps, for lower molar, cow-horn, either side.
Two elevators, Nos. 6 and 7, for lifting roots of bicuspids and molars.
One ebony-handle gum lancet.

No. 8.—OBSTETRICAL CASE.

(Arranged by Surgeon B. E. Fryer, U. S. A.)

One Wallace's modification of Hodgen's forceps.
One Briehell's small forceps.
One vectis.
One Thomas's perforator.
One blunt hook and crotchet.
One Mundie's cranio-clasp.
One uterine-tube, to fit Davidson's self-injecting syringe.
One set of Barnes's dilators.
One cylindrical dilator.
One placenta-forceps.

One Fryer's transfusion apparatus for mediate or immediate transfusion.
One Sims's catheter.
Two flexible catheters.
One bottle for chlo. of iron, sol.
One bottle ergotine.
One bottle Little's saline mixture.
Uterine instruments:
One Sims's speculum with Nott's attachment.
One Sims's repositor.
One Simpson's sound.
One Emmet's applicator.
One pair curved scissors.
One dozen Lea's tangled tents.
One dozen sponge-tents.

No. 9.—Case of Urethral Instruments (arranged by Assistant Surgeon A. H. Hoff, U. S. A.)

No. 10. Esmarch's bandage and tourniquet.
No. 11. Spray apparatus.
No. 12. Rubber syringe, self-injecting.
No. 13. Rubber syringe, self-injecting, with colpeurynter
No. 14. Universal syringe.
No. 15. Aspirator.
No. 16. Scarificator (for cupping).
No. 17. Irrigator.
No. 18. Artificial leech.
No. 19. Stethoscope.
No. 20. Hypodermic syringe.
No. 21. Clinical thermometer.
No. 22. Ophthalmoscope (Knapp's pattern).
No. 23. Compound speculum (Sims's pattern
No. 24. Steam atomizer.
No. 25. Stomach pump.
No. 26. Portable electro-magnetic machine. Manufactured by the Galvano-Faradic Manufacturing Company, New York.

Case No. 2. contains miscellaneous surgical instruments and appliances, and the chest of tools issued to post hospitals:

No. 1. Four air-cushions, of rubber (two with open center).
No. 2. Two double trusses, Common Sense.
No. 3. Two single trusses, Common Sense.
No. 4. Screw tourniquet, with pad.
No. 5. Field tourniquet.
No. 6. Twelve cupping-glasses, assorted sizes.
No. 7. Twelve cupping-tins, assorted sizes.
No. 8. Two glass syringes, penis.
No. 9. Two probangs.
No. 10. Two scissors.
No. 11. Razor, brush, and strop.
No. 12. Hone.
No. 13. Thumb-lancet.
No. 14. Two metal plates for dressings.
No. 15. Nipple-shields, India rubber.
No. 16. Glass syringe for vagina.
No. 17. Hard-rubber syringe for vagina.
No. 18. Hard-rubber syringe for enema.
No. 19. Speculum for vagina.
No. 20. Sponge-holder.
No. 21. Two rubber syringes for penis.
No. 22. Leather trunk for surgical case.
No. 23. Tongue depressor.
No. 24. Chest of tools containing the following articles: One hand-saw, one steel hammer, one large farrier chisel, one small farrier chisel, one try square, one oil-stone, one rule, one handled auger-bit, large, one handled auger-bit, small, one screw-driver, one pencil, one large brad-awl, one small brad-awl, one gouge, one spirit level, one jack-plane, one chalk-line, one scratch-awl, one oiler, one compass, one reel and awl, one mallet, one nail-set, one large gimlet, one small gimlet, one saw-file, one cold chisel, twenty tools in handles, one hatchet.
No. 25. Patent candlestick, for night operations.

Case No. 3 contains—

No. 1. One water-bed.
No. 2. Two air-pillows.
No. 3. One fire-extinguisher (a small brass pump with hose).
No. 4. Samples of the stationery issued to post hospitals, in accordance with the Supply Table, viz:

	Allowance for six months.					Allowance for three months.	
	Post of one company.	Post of two companies.	Post of four companies.	Post of six companies.	Post of one regiment.	General hospital of 250 beds.	500 men in the field.
STATIONERY.							
Blank books, cap, half bound, 4 quires ..... no..	3	4	4	5	6	10	2
Elastic bands, assorted, gross ..... no..	1	1	1	2	2	3	1
Envelopes, printed, official 50, letter 50 ..... no..	300	300	400	500	600	1,000	300
India rubber ..... pieces..	2	2	3	4	4	8	1
Ink:							
2 oz. bottles ..... no..	4	4	6	6	8	24	4
Carmine, in 1 oz. bottles ..... no..	2	2	3	4	5	6	1
Mucilage ..... bott..	1	1	2	2	3	4	.....
Paper:							
Blotting ..... qrs..	½	½	½	1	1	2	½
Filtering, round, grey, 10 inches ..... packs..	1	1	1	2	2	2	.....
Litmus, blue and red, of each ..... sheets..	2	2	2	2	2	4	.....
Wrapping, white and blue ..... qrs..	2	4	6	8	10	12	2
Writing: cap, 1 quire; letter, 2 quires; note, 1 quire .... qrs..	16	16	24	32	48	96	8
Pencils, lead ..... no..	6	6	12	12	18	48	6
Penholders ..... no..	4	6	8	10	12	24	2
Pens, steel ..... no..	48	48	72	96	96	120	48
Sealing wax ..... sticks..	1	1	2	3	4	6	.....
Tape, red ..... pieces..	1	1	2	2	2	4	.....

Case No. 4 contains meteorological instruments issued to post hospitals, viz:

No. 1. Two standard thermometers.
No. 2. Maximum and minimum thermometers.
No. 3. Rain gauge and glasses.
No. 4. Barometer (hung by the east window).
Microscope.
No. 5. Beck's popular (binocular) microscope, with 1¼ inch objectives. These instruments are issued to medical officers on special requisition, subject to the approval of the Surgeon-General.

MISCELLANEOUS SURGICAL INSTRUMENTS.

(Not on the Supply Table.)

No. 6. Dr. J. T. Hodgen's double-acting elastic stomach-pump (designed also as a syringe for the bowels, vagina, or bladder).
No. 7. Dr. J. T. Hodgen's apparatus for transfusion.
No. 8. Dr. J. T. Hodgen's urethral snare.
No. 9. Dr. J. T. Hodgen's hair-pin retractors.
No. 10. Dr. Norman Gay's splint for fracture of leg.

No. 11. Amputating set, used in the United States Army during the Seminole war in Florida, 1835–'37.

No. 12. Amputating set used during the Mexican war. Articles used by Dr. Benjamin Tredwell on board a man-of-war during the Revolution.

No. 13. Amputating set supposed to have been used during the war of 1812.

No. 14. English amputating case, captured from the blockade-runner Bermuda.

Case No. 5 contains:

No. 1.—*Medical and surgical books issued to post hospitals, in accordance with the Standard Supply Table, viz:*

Articles.	Outfit allowance for—							
	Temporary post.	Post of one company.	Post of two companies.	Post of four companies.	Post of six companies.	Post of one regiment.	General hospital of 250 beds.	500 men in the field.
Anatomy, Gray's ..... copy..	1	1	1	1	1	1	1	1
Bumstead on Venereal ..... copy..	....	1	1	1	1	1	1	....
Chemistry, Fowne's ..... copy..	....	1	1	1	1	1	1	....
Children, Diseases of, Meigs & Pepper, or Vogel ..... copy..	....	1	1	1	1	1	1	....
Cohen on Diseases of the Throat ..... copy..	....	1	1	1	1	1	1	....
Craig on the Decimal System ..... copy..	....	1	1	1	1	1	1	....
Diagnosis, De Costa's ..... copy..	1	1	1	1	1	1	1	....
Dictionary:								
English, Worcester's ..... copy..	....	1	1	1	1	1	1	....
Medical, Dunglison's ..... copy..	1	1	1	1	1	1	1	....
Diseases of Women, Thomas' ..... copy..	....	1	1	1	1	1	1	....
Dispensatory ..... copy..	1	1	1	1	1	1	1	1
Ear, Tröltsch on ..... copy..	....	1	1	1	1	1	1	....
Eye, Stellwag on ..... copy..	....	1	1	1	1	1	1	....
Garretson on the Diseases and Surgery of the Mouth, Jaws, and Associated Parts ..... copy..	....	1	1	1	1	1	1	....
Histology, Stricker's ..... copy..	....	....	1	1	1	1	1	....
Hygiene, Parke's ..... copy..	1	1	1	1	1	1	1	1
Jurisprudence, Taylor's or Stillé & Wharton ..... copy..	....	....	1	1	1	1	1	....
Meteorology, Loomis' ..... copy..	....	1	1	1	1	1	1	....
Midwifery:								
Hodge's ..... copy..	....	....	....	....	1	1	....	....
Cazeaux' ..... copy..	....	1	1	1	1	1	....	....
Ophthalmoscope, Zander ..... copy..	....	....	....	1	1	1	1	....
Pathology, Surgical, Billroth's ..... copy..	....	....	1	1	1	1	1	....
Physics, Ganot's ..... copy..	....	1	1	1	1	1	1	....
Physiology, Flint's ..... copy..	....	1	1	1	1	1	1	....
Practice of Medicine:								
Flint's ..... copy..	1	1	1	1	1	1	1	1
Wood's ..... copy..	....	....	....	1	1	1	1	....
Reynold's ..... copy..	....	....	....	1	1	1	1	....
Aitken's ..... copy..	....	....	....	....	1	1	1	....
Niemeyer's ..... copy..	....	1	1	1	1	1	1	....
Recruits, Examination of, Tripler's ..... copy..	....	1	1	1	1	1	1	....
Skin, Diseases of, Tilbury Fox ..... copy..	....	1	1	1	1	1	1	....
Surgery:								
Erichsen's ..... copy..	1	....	....	1	1	1	1	1
Gross' ..... copy..	....	1	1	1	1	1	1	....
Holmes' ..... copy..	....	....	....	....	1	1	1	....
Guthrie's Commentaries ..... copy..	1	1	1	1	1	1	1	1
Therapeutics:								
Stillé's ..... copy..	....	....	....	1	1	1	1	....
Waring's ..... copy..	1	1	1	1	1	1	1	1
Mechanical, Wales' ..... copy..	....	1	1	1	1	1	1	....
Woodward on "Camp Diseases" ..... copy..	....	1	1	1	1	1	1	1
Woodward's Hospital Steward's Manual ..... copy..	1	1	1	1	1	1	1	1

And the following works added to the Supply Table since the last edition was printed, viz:

Surgery, Ashurst's.
Genito-Urinary Diseases, Van Buren and Keyes.
Cyclopædia of Practical Medicine, Ziemsen's.
Therapeutics, H. C. Wood's.
Diseases of the Ear, Roosa's.
The Microscope, Frey's.

No. 2.—*Medical periodicals issued to medical officers of the Army from the Surgeon-General's Office.*

Medical Times and Gazette. London (weekly).

Philadelphia Medical Times. Philadelphia. A bi-weekly journal of medical and surgical science.

The Medical Record; a weekly journal of medicine and surgery. New York.

The Boston Medical and Surgical Journal; a weekly journal of medicine and surgery.

The Medical News and Library. Philadelphia (monthly).

New Remedies; a monthly trade journal of materia medica, pharmacy, and therapeutics. New York.

Braithwaite's Retrospect of Practical Medicine and Surgery. (Half-yearly.)

The American Journal of Medical Sciences (quarterly). Philadelphia.

No. 3.—*Blank books for record purposes, &c., as authorized by the Standard Supply Table, viz:*

Articles.	Outfit allowance for—							
	Temporary post.	Post of one company.	Post of two companies.	Post of four companies.	Post of six companies.	Post of one regiment.	General hospital of 250 beds.	500 men in the field.
Case, Diet and Prescription Book ..... no.	1	1	1	1	1	1	1	....
Morning Report Book ..... no.	1	1	1	1	1	1	1	1
Order and Letter Book ..... no.	1	1	1	1	1	1	1	1
Record of Deaths ..... no.	....	1	1	1	1	1	1	....
Register:								
Meteorological ..... no.	....	1	1	1	1	1	....	....
Of Patients ..... no.	1	1	1	1	1	1	1	....
Of Patients, small, flexible covers ..... no.	....	....	....	....	....	....	....	1
Surgical Operations ..... no.	....	....	..	1	1	1	1	....
Regulations, Army ..... no.	1	1	1	1	1	1	1	1

Case No. 6 contains:

No. 1. Blank forms used by the Medical Department of the Army for reports, &c., viz:
Merit Roll Army Medical Board.
Inventory and Inspection Report.
Report of Stations and Posts in the Department of ———
Invoice of Durable Articles purchased with Hospital Fund.
Blank voucher for Medical Attendance rendered.
Return of Durable Property purchased with Hospital Fund.
Invoice of Medical Supplies.

Receipts for Medical Supplies.
Hospital Muster Rolls.
Meteorological Register for the month of ———
Form 42.—Nomenclature to be followed in making the monthly Report of Sick and Wounded.
Special Diet form for Post Hospitals.
Return of Medical Property. (Duplicate, triplicate, and original.)
Case, Diet, and Prescription Form.
Statement of Hospital Fund. (Monthly.)
Requisition of Medical Supplies.
Return of Hospital Stewards serving in Department of ———.
Return of Medical Officers.
Sanitary Report, year ending ——— —, ——.
Monthly Report of Sick and Wounded.
List of Wounded remaining under Treatment.
Classified Return of Wounds and Injuries received in Action.
Report of Surgical Operations. (Quarterly.)
Report of Wounded. (Quarterly.)
Record of Variation of Temperature (of patients).
Monthly Report of Examination of Recruits.
Diagram of the Areas of Physical Signs.

No. 2. Set of the Publications of the Surgeon-General's Office, viz:

Statistical Report on the Sickness and Mortality in the Army of the United States, January, 1819, to January, 1839. Prepared under the direction of the Surgeon-General. Washington, 1840. iv, 5-346 pp. 8vo.

Statistical Report on the Sickness and Mortality in the Army of the United States, January, 1839, to January, 1855. Prepared under the direction of the Surgeon-General by Assistant Surgeon R. H. Coolidge. Washington: 1856. pp. 703. 4to.

Statistical Report on the Sickness and Mortality in the Army of the United States, January, 1855, to January, 1860. Prepared under the direction of the Surgeon-General by Assistant Surgeon R. H. Coolidge. Washington: 1860. pp. 515. 4to.

Army Meteorological Register; 1831 to 1842, inclusive. Prepared under the direction of the Surgeon-General. Washington: 1851. pp. 324. 8vo.

Army Meteorological Register; 1843 to 1854, inclusive. Prepared under the direction of the Surgeon-General. Washington: 1855. pp. 763. 4to.

Circular No. 1. Surgeon-General's Office, June 10, 1868. Report on Epidemic Cholera and Yellow Fever in the Army of the United States during the year 1867. By Bvt. Lieut. Col. J. J. Woodward, assistant surgeon, U. S. A. xxxix. pp. 156. 4to.

Circular No. 2. Surgeon-General's Office, January 2, 1869. A Report on Excisions of the Head of the Femur for Gunshot Injury. By Bvt. Lieut. Col. G. A. Otis, assistant surgeon, U. S. A. pp. 141. 4to.

Circular No. 3. Surgeon-General's Office, August 17, 1871. A Report of Surgical Cases treated in the Army of the United States from 1865 to 1871. By Bvt. Lieut. Col. G. A. Otis, assistant surgeon, U. S. A. pp. 296. 4to.

Circular No. 4. Surgeon-General's Office, December 5, 1870. A Report on Barracks and Hospitals, with descriptions of Military Posts. By Bvt. Lieut. Col. J. S. Billings, assistant surgeon, U. S. A. xxxiii. pp. 494. 4to.

Circular No. 5. Surgeon-General's Office May, 4, 1867. Report on Epidemic Cholera in the Army of the United States during the year 1866. By Bvt. Lieut. Col. J. J. Woodward, assistant surgeon, U. S. A. xviii. pp. 65. 4to.

Circular No. 6. Surgeon-General's Office, November 1, 1865. Report on the Extent and Nature of the Materials available for the Preparation of a Medical and Surgical History of the Rebellion. By Assistant Surgeons G. A. Otis and J. J. Woodward, U. S. A.

Circular No. 7. Surgeon-General's Office, July 1, 1867. A Report on Amputations at the Hip-joint in Military Surgery. By Bvt. Lieut. Col. G. A. Otis, assistant surgeon, U. S. A.

Circular No. 8. Surgeon-General's Office, May 1, 1875. A Report on the Hygiene of the United States Army, with descriptions of Military Posts. By Bvt. Lieut. Col. J. S. Billings, assistant surgeon, U. S. A. lix. pp. 567. 4to.

Catalogue of the Army Medical Museum, Surgical Section, by Bvt. Maj. A. A. Woodhull, assistant surgeon U. S. A. Government Printing Office: 1866. pp. 664. 4to. Medical Section by Bvt. Lieut. Col. J. J. Woodward, assistant surgeon, U. S. A. Government Printing Office: 1867. pp. 136. 4to. Microscopical Section by Bvt. Maj. E. Curtis, assistant surgeon, U. S. A. Government Printing Office: 1867. pp. 160. 4to.

List of Skeletons and Crania in the Section of Comparative Anatomy of the Army Medical Museum. By Dr. H. C. Yarrow. Washington: 1876. pp. 52. 8vo.

Check List of Preparations and Objects in the Section of Human Anatomy, &c. By Bvt. Lieut. Col. George A. Otis, assistant surgeon, U. S. A. Washington: 1876. pp.

Catalogue of the Library of the Surgeon-General's Office. By Bvt. Lieut. Col. J. S. Billings, assistant surgeon, U. S. A.

Vol. I. Authors A to L. Government Printing Office, 1873. pp. 1193. 4to.

Vol. II. Authors, L to Z. Government Printing Office, 1874. pp. 956. 4to.

Vol. III. Supplement. Government Printing Office, 1874. pp. 319. 4to.

Specimen Fasciculus of a Catalogue of the National Medical Library. Under the direction of the Surgeon-General, U. S. A., at Washington, D. C. By Bvt. Lieut. Col. J. S. Billings. Washington, 1876. pp. 72. 4to.

Historical Notes concerning the Medical Department of the United States Army from 1775 to 1873. By Bvt. Maj. H. E. Brown, assistant surgeon, U. S. A. Washington: 1873. pp. 314. 8vo.

The Medical and Surgical History of the War of the Rebellion (1861-'5.) Prepared under the direction of the Surgeon-General. Part I, vol. I. Medical History, by Assistant Surgeon J. J. Woodward, U. S. A. Government Printing Office: 1870. pp. 726. 4to. Appendix to Part I, containing reports of Medical Directors, and other documents. pp. 366. 4to. Vol. II, Surgical History, by Assistant Surgeon G. A. Otis, U. S. A. Government Printing Office: 1870. pp. 650. 4to. Part II, vol. II, Surgical History, by Assistant Surgeon G. A. Otis, U. S. A. Government Printing Office: 1876. pp. 1024. 4to.

Statistical, Medical, and Anthropological of the Provost-Marshal-General's Bureau. By Col. J. H. Baxter, Chief Medical Purveyor, U. S. A. Government Printing Office: 1875. Vol. I, pp. 568, vol. II, pp. 767. 4to.

No. 3. Surgical photographs, viz:

Six volumes (large quarto) of Photographs of Surgical Cases and Specimens, prepared under direction of the Surgeon-General by Bvt. Lieut. Col. G. A. Otis, assistant surgeon, U. S. A.

Vol. I.—50 photographs.
Vol. II.—50 photographs.
Vol. III.—50 photographs.
Vol. IV.—50 photographs.
Vol. V.—50 photographs.
Vol. VI.—52 photographs.

No. 4. Photographs of Books, viz:

Two volumes (large quarto) of photographs representing rare books in the National Medical Library. Prepared by Bvt. Lieut. Col. J. J. Woodward, assistant surgeon, U. S. A. Army Medical Museum: 1876.

Vol. I.—54 photographs.
Vol. II.—50 photographs.

CONTENTS.

1. Specimen page from a fine manuscript of the "Lilium Medicinæ," of Bernard de Gordon.
[This is the oldest MS. in the Library, and is dated 1349. See No. 27.]
2. First page of the treatise of Paul Bagellardus, "Libellus de Egritudinibus infantium." 1472.
3. Last page of the treatise of Paul Bagellardus, "Libellus de Egritudinibus infantum." 1472.
[This is the first printed monograph on the diseases of children.]
4. First page of the Aggregator de Medicinæ Simplicibus of Jacob Dondus Paduanus.
[Folio, without place or date. Probably printed at Strasburg, by J. Mentelia, about 1470. It is the editio princeps.]
5. Title-page of the treatise of Valescus de Tarranta "De epidimia et peste."
[Without place or date; probably printed at Argentorati about 1470.]
6. First page of the first edition of the "Liber de complexionibus, proprietatibus, electionibus operationibus que laxativarum. Practica de Medicinis particularium ægritudinum," by John, son of Mesua. Venice. 1471.
7. First page of the manual of the practice of medicine, by Arnold de Villa Nova.
[Without place or date. According to Brunet, it ts printed with type used at Mantua in 1473.]
8. Title-page of the "Regiment der jungen Kinder." Printed at Augsburg in 1473.
9. First page of the treatise on diseases of the eye, of Benevenutus Grassus. Printed at Ferrara. 1475.
[The first printed monograph on diseases of the eye.]
10. First page of the Pandects of Matthew Silvaticus. In folio.
[Without place or date. Hain, No. 15,192. Probably printed at Strasburg about 1475.]
11. Last page of the Editio princeps of the "Suma conservationis et curationis" of William de Salicet. 1476.
12. First page of the "Tractatus de Regimine Sanitatis" of Benedictus de Nursia. Printed at Bononia. 1477.
13. Last page of the first edition of Celsus. Printed at Florence. 1478.
14. First page of Canon of Avicenna, in folio. Printed at Patavia. 1479.
15. First page of the "Artzneibuch" of Ortolff von Beyrlant. Printed at Augsburg. 1479.
16. First page of the first edition of the works of Petrus Argelata or de la Cerlata. Edited by M. Moretus; printed at Venice in 1480.
[In the original the initial letters are illuminated.]
17. Title-page of the Anatomy of Mundinus.
[Without page or date. Hain, No. 11,633.]
18. First page of the Regimen Sanitatis of the school of Salernum. With the Commentary of Arnold de Villa Nova. 1480.
19. Last page of the first edition of the "Liber de Medicina" of Averroes. Venice. 1482.
20. First page of a rare edition of the works of Mesua. Printed at Venice. 1484.
21. First page of the the treatise on poisons of Petrus de Abano. 1487.
22. Last page of the "Practica" of Valescus de Tarranta. Printed at Lyons. 1478.
[Hain, No. 15,249, says it is without doubt 1488.]
23. First page of the edition of the "Liber Theicrise" of Avenzohar. Printed at Venice. 1490.
24. Page of the "Ortus Sanitatis" of Meydenbach. Printed at Moguntia in 1491.
[The figures in the original are colored.]
25. Second page of the collection of medical tracts know as "Articella." Printed at Venice. 1493.
26. First page of the treatise on medicine of Arnold de Villa Nova. Printed at Venice. 1494.

27. Last page of the "Lilium Medicinæ" of Bernard de Gordon. Venice. 1496.
[See No. 1.]

28. Title page of the tractate on syphilis, by Grunpeck de Burckhausen.
[Without place or date. Probably printed at Augsburg in 1497.]

29. First page of treatise on syphilis of John Widman. 1497.

30. First page of the treatise of Gaspar Torrella on syphilis. Printed at Rome about 1498.

31. Title-page of the treatise of Jerome of Brunswick on epidemics and the pest. 1500.
[Contains some very curious and spirited wood-cuts.]

35. Title-page of the fasciculus of John de Ketham. Printed at Venice. 1500.
[A collection similar to the "Articella," No. 25. For specimen of the wood-cuts see No. 40.]

33. Commencement of an anonymous treatise on the pest.
[Without place or date. Hain, No. 12,745. Prior to 1500, A. D.]

34. Last page of the "Practica nova medicinè" of John de Concoregia. Venice. 1501.

35. Last page of the treatise on anatomy by Mundinus. 1507.

36. First page of the "De Swangern frawen und hebammen Rosegarten," by Eucharus Roeslyn. Printed at Argentorati. 1513.
[This is the original edition. In Latin it is the "De partu hominus" of Eucharius Rhodion, and is translated into English by Raynalde under the title of "The Woman's Book."]

37. Title-page of a collection of medical tracts printed at Venice in 1508.

38. Title-page of a collection in folio, printed at Venice, by George Arrivabenus, 1514.

39. Title-page of the works of Albucasis. Printed at Augustæ-Vindelicorum. 1519.

40. Specimen plate from the fasciculus of John de Ketham. Italian version. Venice. 1520.
[See No. 32.]

41. Second page of the treatise of Ulrich de Hutten on guiac and syphilis. Printed at Bononia. 1521.

42. Title-page of the first volume of the Aldine edition of Galen. Venice. 1545.

43. Last page of the "Secreta Secretorum" of Aristotle. Printed in 1528.

44. Title-page of the Aldine edition of the Greek text of Paulus Ægineta. 1528.

45. Title-page of a pamphlet of four leaves on the sweating sickness. Printed by Anthony Peypus, the younger. 1529.

46. Page from leaf CXIII of the treatise of Bertholomeus, "De proprietatibus rerum." Printed at London, by Thomas Berthelet. 1535.

47. Title-page of a collection of pamphlets on syphilis, printed at Basel in 1536.

48. Title page of Vesalius' "De humani corporis fabrica, libri septem." Basileae. 1543.
[First edition. Plates engraved under the direction of Titian.]

49 and 50. Copy of an autograph poem by Philip Melancthon, "De consideratione humani corporis." Written on the fly-leaf of the copy of the first edition of Vesalius' "De humani corporis."
[See No. 48.]

51. Title-page of the treatise on medicine by Gometius Pereira. 1558.
[A very rare book.]

52. Title-page of the first medical journal printed in German; being a translation of the "Journal des nouvelles decouvertes" of Nicolas de Blegny. 1680.
[Probably only the volume for this year was printed.]

53. Title-page of the fourth volume of the "Zodiacus medico-gallicus." A reprint in Latin of the first French medical journal—the "Journal des nouvelles découvertes," by de Blegny. 1685.
[This reprint continued five years under the supervision of Theodore Bonet, at Geneva.]

54. Title-page of a volume containing many water-color drawings of monsters, with MS. descriptions.
55. Title-page of "The noble experyence of the vertuous handy-warke of sugeri," being a translation of the "Hantwerck" of Jerome of Brunswick. London. 1525.
[See No. 57.]
56. Title-page of the "Practica in arte chirurgica" of John de Vigo. Printed at Lyons. 1521.
57. Title-page of the "Hantwerck der Cirurgien," by Jerome of Brunswick. Printed at Utrecht. 1535.
[For English translation see No. 55.]
58. Title-page of the work of Alphonsus Ferrius, "De Sclopetorum sive archibusorum vulneribus." Rome. 1552.
59. Title-page of the "Feldtbuch der Wundtartzney," by Hans von Gersdorf, called Schylhans. Franckfurt A. M., 1551.
60. Title-page of the first edition of the "Dix livres de la chirurgie" of Ambrose Paré. Paris. 1564.
61. Commencement of the "Historiall Expostulation against the Beastlye abusers, bothe of Chyrurgerie and Physike," by John Halle. Printed with his translation of the "Chirurgia parva Lanfranci, lanfranke of Mylayne, his briefe." Printed at London. 1565.
62. Title-page of the first edition of the treatise on the pest, small-pox and measles, by Ambrose Paré. Printed at Paris. 1568.
63. Title-page of the first edition of the "Deux livres de chirurgie" of Ambrose Paré. Paris. 1573.
64. Page containing a portrait of Ambrose Paré. Taken from the folio edition of his works in French, published at Paris, 1575.
[The first edition.]
65. Title-page of the Manual of Surgery of Schylander. Antwerp. 1577.
66. Title-page of the "Officinne et Jardin de Chirurgie Militaire" of Le Lievre. Paris 1583.
67. Page 65 of "Certain works of Chirurgie compiled by Thomas Gale." London. 1856.
68. Title-page of the English translation of "Arceus." Printed at London. 1588.
69. Title-page of the "Cirugia Universale of Gio. Andrea dalla Croce." Venice. 1605.
70. Title-page of the "Treatise on Gunshot wounds," of Franciscus Plazzoni. Venice. 1618.
71. Title-page of the first edition of the "Treatise on the Movements of the Heart and circulation of the Blood" by William Harvey. Francfurt. 1628.
72. Title-page of the "Hoplocrisma spongus, or a sponge to wipe away the *weapon-salve*," by William Foster. London. 1631.
73. Title-page of the "Viaticum" of John Woodall. London. 1639.
74. Last page of the "Institucion of Chyrurgerie," by Thomas Gaille. London. 1567.
75. Title-page of "La grande chyrurgie" of Guy de Chauliac. Bordeaux. 1672.
76. Title-page of "Severall Chirurgicall Treatises," by Richard Wiseman. London. 1676.
77. Title-page of the "Treatise on Surgery" of Matthew Godfried Purmann. Franckfurt und Leipzig. 1692.
78. Title-page of the Treatise of Purmann, containing fifty cases of gunshot wounds. Franckfurt und Leipzig. 1721.
79. Title-page of the first edition of the Treatise of Park on Excisions of the Joints. London. 1783.
80. Title-page of the "Reflexions sur les playes," by C. F. Faudacq. Namur. 1735.
81. Title-page of the "Treatise on Wounds" of J. D. Schlichting. Amsterdam. 1748.
82. Title-page of the "Traité des plaies d'armes à feu," by M. Desport. Paris. 1749.

83. Title-page of Volume I of the "Collection of Observations in the Military Hospitals," by Richard de Hautesierck. Paris. 1766.
[This is one of the most valuable works in connection with the history of Military Surgery in France, and is very rare.]

84. Title-page of the "Joyfull newes Out of the New-found Worlde," being a translation of "Monardus," by John Frampton. London. 1596.

85. Thatcher's "Brief rule to guide the Common-People of New England how to order themselves and theirs in the Small-Pocks, or Measels." Boston. 1677.
[From an autotype reproduction of the original broad-side sheet in the Library of the Massachusetts Historical Society.]

86. Title-page of the "Principia Medicinæ" of Ossorio. Printed at Mexico in 1685.

87. Title-page of the Inaugural Thesis of William Bull, of South Carolina, "De colica pictonum." Leyden. 1734.
[Bull was the first American graduate of medicine.]

88. Title-page of the treatise of William Douglass on "The Practical History of a New Epidemical Eruptive Miliary Fever with an Angina Ulcusculosa Which Prevailed in Boston, New England, in the years 1735 and 1736." Boston. 1736.

89. Title-page of the Inaugural Dissertation of John Moultrie, of South Carolina, on the "Yellow Fever." Edinburgh. 1749.
[John Moultrie was the first American graduate at Edinburgh.]

90. Title-page of the Essay on Inoculation, by Laughlin Macleane. Philadelphia. 1756.

91. Title-page of the Inaugural Dissertation of John Morgan, "De puris confectione." Edinburgh. 1763.

92. Title-page of the Inaugural Discourse on "Medical Schools in America," by John Morgan. Philadelphia. 1765.

93. Title-page of the Inaugural Dissertation of Benjamin Rush, "De coctione ciborum in ventricula." Edinburgh. 1768.

94. Title-page of the Inaugural Dissertation of James Tilton, one of the first graduating class at the Medical College of Philadelphia. Philadelphia. 1771.

95. Dedication from the Thesis of Jonathan Potts, one of the first class of graduates of the Medical College at Philadelphia. Printed at Philadelphia. 1771.

96. Title-page of the Dissertation of Jonathan Elmer, one of the first class of graduates of the Medical College at Philadelphia. Philadelphia. 1771.

97. Title-page of the Inaugural Dissertation of Peter de Sales la Terriere, on "Puerperal Fever." Boston. 1789.
[Being the first printed Medical Dissertation of the University at Cambridge.]

98. Title-page of the first number of the Medical Transactions of the Massachusetts Medical Society. Boston. 1790.

99. Title-page of a "Journal of the Practice of Medicine," &c., printed at New York about 1790 (?) Being a reprint of a portion of the "Military Medical Journal" of De Horne.

100. Specimen page from a pamphlet of "Certificates of the efficacy of Doctor Perkins patent metallic instruments." Printed at Newburyport. 1796.

101. Title-page of the Treatise of James Tilton on Military Hospitals. Wilmington. 1813.

102. Title-page of the first volume of the Ohio Medical Repository. Cincinnati. 1827.
[A very rare medical journal.]

03. Title-page of the "Journal de la Société Médicale de la Nouvelle-Orléans." New Orleans. 1839.
[The first medical periodical published in the South; very rare.]

104. First page of the Confederate States Medical and Surgical Journal. Richmond. 1864.
[This was the only medical journal published in the South at this date.]

No. 5. Photomicrographs, by several authors, viz:

Photomicrographs by Prof. J. W. Draper, of New York. This is a volume of nine photographs (large quarto), copied at the Army Medical Museum from daguerreotypes of microscopical objects made by Professor Draper in 1850–'52. The special interest attaching to these photographs is that the daguerreotypes were the first of microscopic objects made in America, and that they were made by Professor Draper by sunlight passed through a cell containing the ammonia-sulphate of copper; a method original with him, which has since been found indispensable to success in photomicrography.

Photographs of the gray substance of the medulla oblongata and trapezium. By John Dean, M. D. 1864. These are the original photographs from which, by photolithography, were prepared the plates illustrating Dr. Dean's work on the gray substance of the medulla oblongata and trapezium. (Smithsonian Contributions to Knowledge, No. 173.) The photographs are thirty-six in number, and all taken with quite low powers.

Twelve photomicrographs made by Drs. William Thomson and W. F. Norris (then assistant surgeons United States Army), in 1864, with a small Zentmayer's microscope. Powers 17–250 diameters.

No. 6. Ten volumes of photomicrographs (large quarto), made at the Army Medical Museum by Bvt. Lieut. Col. J. J. Woodward, assistant surgeon U. S. A.

Vol. I. Magnesium, Electric, Calcium lights, and Sunlight. This volume contains the following papers and photographs. (*a*) Report to the Surgeon-General on the Magnesium and Electric Lights, as applied to Photomicrography. January 5, 1870. pp. 6. 4to, with 11 photographs. Magnified 40 to 2,500 diameters. (*b*) Report to the Surgeon-General on the Oxycalcium Light as applied to Photomicrography. June 4, 1870. pp. 3. 4to, with 2 photographs. Magnified 35 to 1,000 diameters. (*c*) Report to the Surgeon-General on the improved Method of Photographing Histological Preparations by Sunlight. July 13, 1871. pp. 10. 4to, with 9 photographs of histological preparations. Magnified 400 to 960 diameters.

Vol. II. Histology of Minute Bloodvessels and Miscellaneous Histological Photographs. (*a*) Report to the Surgeon-General on certain points connected with the Histology of Minute Bloodvessels. July 6, 1870. pp. 8. 4to, with 11 photographs. Magnified 400 to 1,000 diameters. (*b*) Thirty-four miscellaneous histological photographs. Magnified 70 to 1,000 diameters, representing epithelium, cartilage, bone, teeth, cornea, muscle, the pleuro-pneumonia of cattle, &c.

Vol. III. The Mosquito, &c., containing, (*a*) Letter to the Surgeon-General on the Mosquito. January 5, 1872. With 7 photographs. Magnified 11 to 1,400 diameters. (*b*) Letter to the Surgeon-General on certain Parasites. January 10, 1872. With 10 photographs. Magnified 30 to 135 diameters. (*c*) Letter to the Surgeon-General on the Proboscides of certain Flies. January 15, 1872. With 7 photographs. Magnified 16 to 155 diameters. (*d*) Letter to the Surgeon-General accompanying 11 miscellaneous photographs of insects and parts of insects. January 20, 1872. Magnified 12 to 400 diameters.

Vol. IV. Pleurosigma, Surivella, and Podura. (*a*) Memorandum on Pleurosigma angulatum and P. formosum. June 9, 1871. With 11 photographs. Magnified 380 to 4,500 diameters. (*b*) Memorandum on Surivella gemma. February 1, 1871. With 2 photographs. Magnified 1,300 and 3,100 diameters. (*c*) Memorandum on the Test Podura. February 22, 1871. With 10 photographs of Degeeria domestica and Lepidocystus curvicollis. Magnified 682 to 3,200 diameters.

Vol. V. Miscellaneous photomicrographs of Diatoms, &c., containing 29 photographs. Magnified 25 to 1,100 diameters, representing Triceratium, Coscinodiscus, Heliopelta, Navicula, Grammatophera, &c.

Vol. VI. Nobert's Plate, Webb's Test, Amphipleura pellucida, &c. (*a*) Memorandum on the nineteen-band test plate of Nobert. September 29, 1872. With nine photographs. Magnified 1,100 to 2,500 diameters. (*b*) Webb's Test (the Lord's Prayer written with the diamond in a space $\frac{1}{25}$ inch by $\frac{1}{44}$ inch or the $\frac{1}{1100}$th of a square inch) with the first seven bands of Nobert's Plate for comparison. 3 photographs. Magnified 650 to 825 diameters. (*c*) Photomicrographs of Amphipleura pellucida, with various objectives. 6 photographs. Magnified 960 to 1,725 diameters. (*d*) Amphipleura Sullivantii. 3 photographs. Magnified 700 to 1,400 diameters. (*e*) Stauroneis spicula. 1 photograph. Magnified 1,500 diameters.

Vol. VII. Frustulia saxonica, Navicula rhomboides, Body-scale of the Mosquito and Gnat. (*a*) Six photographs of Frustulia saxonica to illustrate the true appearance and diffraction lines. Magnified 1,600 to 1,830 diameters. (*b*) Two photographs of a small frustule of Navicula rhomboides from Bemis Lake. Magnified 1,700 diameters—one to show transverse striæ, the other beads. (*c*) Six photographs of Navicula rhomboides, showing transverse markings, longitudinal markings, and beads. Magnified 580 to 2,700 diameters. (*d*) Seven photographs of the Body-scale of the English Gnats and the American Mosquito; some showing the true markings, others spurious beads. Magnified 1,300 to 1,500 diameters.

Vol. VIII. Cancer. Seventy-four photographs. Magnified 26 to 1,000 diameters. From preparations in the Microscopical Section of the Museum, to illustrate the structure of cancerous growths and the mode in which the adjacent tissues are invaded.

Vol. IX. Fibers of Wool, Calf-hair, &c. Twenty-five photographs. Magnified 105 to 310 diameters. These photographs were prepared to illustrate a report to the Secretary of the Treasury by a Commission of the National Academy of Sciences, on the subject of certain fabric imported into the United States under the designation of "calf-hair goods."

Vol. X. Blood Corpuscles of Man, Dog, &c. In preparing this series of photographs the blood was spread on a stage-micrometer, so that the corpuscles and micrometer appear together in the photographs, which are magnified 1,000 to 1,100 diameters. There are twenty-six photographs of human blood, thirteen of blood of the dog, four of the guinea pig, and two of the frog.

On the wall of this room are the following pictures:

No. 1. Photograph of Surgeon R. O. Abbott, U. S. A., late medical director of the Department of Washington, &c.

No. 2. Photograph of Surgeon-General C. A. Finley, retired.

The lower panes of the two windows are occupied by photographic transparencies about 10 inches in diameter, from photomicrographs made at the Army Medical Museum, by Bvt. Lieut. Col. J. J. Woodward, assistant surgeon, U. S. A., viz:

No. 3. (*a*) Epidermis of Frog. Magnified 800 diameters. (*b*) Perpendicular section of stomach of frog. Magnified 800 diameters.

No. 4. (*a*) Transverse section of bone (human). Magnified 980 diameters. (*b*) Longitudinal section of bone (human). Magnified 500 diameters.

Room No. 5.

This room is the dining-room of the post hospital, and has been fitted up to contain samples of the mess furniture issued for hospital purposes.

No. 1. Mess-chest, Army pattern.

Basins, tin, small	no.	12	Knife and fork, carving, of each	no.	1
tin, wash-hand	no.	2	Knives and forks, of each	no.	12
Box for pepper	no.	1	Ladles	no.	2
Box for salt	no.	1	Mill, coffee	no.	1
Canister for butter	no.	1	Mugs, britannia, half-pint	no.	12
Canister for coffee	no.	1	Pan, frying	no.	1
Canister for sugar	no.	1	sauce	no.	1
Canister for tea	no.	1	Plates, tin	no.	6
Cleaver	no.	1	Pot, coffee, tin	no.	1
Cups, tin	no.	1	iron	no.	1
Dipper	no.	1	tea, tin	no.	1
Dishes, tin (assorted sizes)	no.	6	Saw, butcher's	no.	1
Grater	no.	1	Spoons, table	no.	12
Gridiron	no.	1	tea	no.	12
Kettle, camp, with cover	no.	1	Tray, tin	no.	1
tea, iron	no.	1	Tumblers, tin	no.	12

No. 2. Mess-chest designed by T. Morris Perot & Co. These chests were largely used by the Medical Department of the United States Army during the war of the rebellion, and were highly appreciated by the surgeons and other officers who used them, being the most compact possible form for carrying the articles desired in a camp-chest. They contain the ordinary articles of a mess-chest, such as camp-kettles, mess-pans, tea-kettle, coffee and tea pot, tin cups and tumblers, frying-pan, gridiron, cans for tea, coffee, sugar, and butter, plates, knives and forks, cook's knife, spoons, ladles, &c., besides which each one has in it a large sheet-iron stove, a tin oven, and a box lantern. The chest when opened forms a good table.

No. 3. Table-ware, &c., issued to post hospitals, as per the Standard Supply Table, viz: Bowls (delft), dishes (assorted sizes), knives (table, carving, bread), forks (table, carving), ladles, mugs (delft and tin), pitchers (delft, two sizes), plates (delft), pots (coffee, mustard, pepper, tea), salt-cellars, spoons (table, tea), tumblers (glass), trays (butlers').

No. 4. Upright self-ventilating refrigerator (made by H. M. Diggins).

Room No. 6.

This is the kitchen of the post hospital. It contains samples of the kitchen furniture issued for hospital purposes, viz:

No. 1. Cooking-ranges, with fixtures complete.

No. 2. Caldron, with tin cover (20 gallons).

No. 3. Articles of kitchen furniture, &c., as per the Standard Supply Table, viz: Brooms, brushes (scrubbing and for stove blacking), clothes-

line, stove-blacking, basins (wash-hand), boards (wash), boilers (tin), buckets (leather, tin, wooden), candlesticks, cleavers, cork-screws, colanders, dippers (tin, assorted), flesh-fork, funnels, graters (nutmeg and large), gridirons, hatchets, hones, knives (butchers'), milk-cans (2 gallon), mills (coffee), pans (frying, sauce, tin), sadirons, saws (butchers', wood), tubs (wash).

Room No. 7.

This room was fitted up as the private office of the medical officer in charge. On the walls were the following pictures:

1. Oil-painting of the late Surgeon-General Lovell, United States Army.
2. Photograph of Surgeon-General J. K. Barnes.
3. Photograph of Assistant Surgeon-General C. H. Crane.
4. Photograph of Chief Medical Purveyor J. H. Baxter.
5. Small photographs of the late Surgeon Josiah Simpson, United States Army.
6. Small photograph of the late Surgeon E. A. Abadie, United States Army.
7. Small photograph of the late Surgeon J. Letterman, United States Army.
8. Small photograph of the late Assistant Surgeon S. Adams, United States Army.
9. The lower panes of the windows were occupied by two photographic transparancies on glass, from photomicrographs made at the Army Medical Museum by Bvt. Lieut.-Col. J. J. Woodward, assistant surgeon, United States Army, viz: (*a*) Transverse section of artichoke. Magnified 75 diameters. (*b*) Proboscis of blow-fly. Magnified 90 diameters.

HALL-WAY OF FIRST FLOOR.

On the walls were the following photographs from the Army Medical Museum:

NINE PHOTOGRAPHS OF AMPUTATIONS OF THE HIP-JOINT.

No. 1. Mott's successful reamputation at the hip. Case of Private L. Francis, Fourteenth New York State Militia.

No. 2. Fauntleroy's successful reamputation at the hip. Case of Private R. A. Viek, Forty-third North Carolina.

No. 3. Packard's successful reamputation at the hip. Case of Private E. E. Smith, Eleventh Maine.

No. 4. Otis's successful reamputation at the hip. Case of Private J. Fabry, Fourth Artillery.

No. 5. Morton's successful reamputation at the hip. Case of Sergeant E. D. Ulmer, Fifteenth New Jersey.

No. 6. Shippen's primary amputation at the hip. Case of Private J. E. Kelly, Fifty-sixth Pennsylvania.

No. 7. Lincoln's successful reamputation at the hip. Case of Private W. Cotter, Ninth New Hampshire.

No. 8. Bentley's successful amputation at the hip. Case of Private G. W. Lemon, Sixth Maryland.

No. 9. Blackman's successful secondary amputation at the hip. Case of Private W. Longmore, C. S. A.

SEVEN EXAMPLES OF RECOVERY FROM EXCISIONS OF THE HEAD OF THE FEMUR FOR SHOT INJURY.

No. 10. Read's successful excision of the head of the left femur. Case of Lieutenant Jarratt, Fifteenth North Carolina.

No. 11. Secondary excision of the head of the left femur. Case of Private C. F. Read, Company I, Thirty-seventh Infantry. By Assistant Surgeon J. R. Gibson, U. S. A.

No. 12. Primary excision of the head of the left femur. Case of Private Hubert Erne, Company D, Fourth Infantry. By Assistant Surgeon Frank Meacham, U. S.A.

No. 13. Intermediary excision of the head of the right femur. Case of Hugh Wright, Company G, Eighth New Jersey. By Assistant Surgeon G. A. Mursick, U. S. V.

No. 14. Secondary excision of the head of the left femur. Case of Private Joseph Brown, Company I, Third Michigan. By Surgeon D. P. Smith, U. S. V.

No. 15. Primary excision of the head of the right femur.

No. 16. Secondary excision of the head of the left femur. Case of Charles B. Scott, U. S. N. By Surgeon W. E. Taylor, U. S. N.

NINE EXAMPLES OF RECOVERY FROM DOUBLE AMPUTATIONS AFTER SHOT INJURY.

No. 17. Amputation of the forearms for injury caused by premature explosion of a gun. Case of Private L. H. Decker, Fourth Artillery.

No. 18. Double amputation of right thigh and left leg. Case of Corporal C. N. Lapham, First Vermont Cavalry.

No. 19. Double amputation of arm at the upper third. Case of Private A. Stratton, One hundred and forty-seventh New York. By Surgeon A. S. Coe, One hundred and forty-seventh New York.

No. 20. Amputation of both feet for gangrene following frost-bite. Case of Private T. Rauthe, Thirteenth New York Cavalry.

No. 21. Double amputation at the ankle-joint, by Syms's method, for railway accident. Case of J. Miller.

No. 22. Amputation of the forearms for injury by a brick-making machine. Case of Franklin Gay.

No. 23. Amputation of both arms. Case of Sergeant Warden, but no further record.

No. 24. Synchronous amputation of both thighs. Case of Private C. G. Rush, Twenty-first Georgia. By Surgeon D W. Bliss, U. S. V.

No. 25. Quadruple amputation for frost-bite. Case of Sergeant J. Pierson, Seventh Infantry. By Assistant Surgeon J. K. Warren, U. S. A.

SECOND STORY.

ROOM NO. 8.

This room contained articles of prothenic apparatus, exhibited by makers who have furnished considerable numbers of artificial limbs, &c., to disabled soldiers and volunteers, under the supervision of the Surgeon-General, in accordance with the act of Congress dated June 30, 1870.

No. 1.—*Prothetic apparatus made by E. D. Hudson, M. D., No. 696 Broadway, New York.*

1. Splint for ununited fractures of lower extremity, for immobility or mobility, extension or counter-extension *pro re nata*, coaptation of fragments, walking exercise, reunion—prothetic for non-union.

2. The same, modified for chronic synovitis of knee and ankle joints.

3. Apparatus for lateral dislocation of knee-joint; genu valgum, rupture of ligamentum patellæ, impaired triceps femoris.

4. Apparatus for locomotion; passive motion; hemiplegia.

5. Apparatus for lead palsy, wrist drop, lesion of nerves of arm and hand.

6. Apparatus for resection of shoulder joint, arm, elbow, forearm.
7. Apparatus for talipes varus; equino varus; valgus et calcaneus.
8. Apparatus for shortened limbs; coxalgia; resection; necrosis, &c.
9. Prothetic apparatus for thigh amputation.
10. Prothetic apparatus for knee-joint and head of tibia amputation.
11. Prothetic apparatus for leg amputations, periosteal covering, &c.
12. Prothetic apparatus for ankle-joint amputations, Syme, &c.
13. Prothetic apparatus for arm and forearm amputations.

No. 2.—*Prothetic apparatus made by D. W. Kolbe, No.* 15 *South Ninth street, Philadelphia.*

1. Artificial arm, for amputation below the elbow.
2. Artificial arm, for amputation above the elbow.
3. Artificial leg, for amputation below the knee.
4. Artificial leg, for amputation above the knee.
5. Apparatus for resection of the forearm.
6. Apparatus for resection of the upper arm.
7. Apparatus for resection of the femur, tibia, fibula, or dislocation of the hip-joint.
8. Prof. Henry A. Smith's apparatus for ununited fracture of the femur.

No. 3.—*Prothetic apparatus made by James H. Foster, No.* 1013 *Chestnut street, Philadelphia.*

1. Artificial leg for thigh amputation.
2. Artificial leg for section of thigh amputation.
3. Artificial leg for amputation of the leg.
4. Artificial arm.

No. 4.—*Prothetic apparatus manufactured by Richard Clement, No.* 1320 *Chestnut street, Philadelphia.*

1. For amputations below the knee.
2. For amputations above the knee.

No. 5.—*Prothetic apparatus manufactured by A. A. Marks,* 575 *Broadway, New York.*

1. For amputation below the knee.
2. For amputation at the knee.
3. For amputation above the knee.

No. 6.—*Prothetic apparatus by the Artificial Limb Manufacturing Company, No.* 279 *Penn street, Pittsburgh, Pa.*

1. For amputation below the knee.

Room No. 9.

This room contained medicine chests, panniers, &c., viz:

No. 1.—Medicine Case. (Regular pattern.)

Acid, sulphuric	oz.	1	Medicine glasses	no.	1
Bandages, roller	no.	24	Muslin, unbleached, unsized, 1 yard wide	yds.	2
Chloroform, purified	oz.	6½	Opium:		
Corks	no.	6	Tincture of (laudanum)	oz.	2
Ginger, fluid extract of	oz.	2	Pills of	no.	200
Ipecacuanha, fluid extract of	oz.	1	Pills of camphor (2 grains) and opium (1 grain)	no.	200
Iron, solution of the subsulphate of	oz.	2	Pills, cathartic compound	no.	200
Lint, patent	lb.	¼			

Pills of sulphate of quinia (grains 3)	no.	200
Plaster, isinglass	yd.	1
Pins	paper.	1
Scissors	pair.	1
Silk, ligature	oz.	¼
Sponge, fine, small	piece.	1
Spoon, tea	no.	1
Towel	no.	1

No. 2.—Medicine Pannier.

Acid:		
Carbolic, crystallized, pure	oz.	2
Citric	oz.	2
Tannic	oz.	½
Aconite root, fluid extract of	oz.	3
Alcohol	oz.	12
Ammonia, solution of	oz.	8
Antimony and potassa, tartrate of (tartar emetic)	oz.	1
Bismuth, subnitrate of	oz.	4
Cerate:		
Blistering	oz.	3
Simple	oz.	16
Chloral, hydrate of	oz.	6
Chloroform, purified	oz.	12
Colchicum seed, fluid extract of	oz.	3
Collodion	oz.	3
Cough mixture (see note).		
Copper, sulphate of	oz.	1
Creosote	oz.	2
Ginger, fluid extract of	oz.	6
Glycerine	oz.	6
Iodine	oz.	1
Ipecacuanha, fluid extract of	oz.	3
Iron:		
Solution of the sulphate of	oz.	4
Tincture of the chloride of	oz.	4
Lead, acetate of	oz.	3
Linament (see note).		
Magnesia, sulphate of	lb.	2
Mercurial ointment	oz.	6
Mercury, corrosive chloride of (corrosive sublimate)	oz.	⅛
Morphia, sulphate of	oz.	¼
Olive oil	oz.	6
Opium:		
Camphorated tincture of	oz.	6
Tincture of (laudanum)	oz.	6
Pepper, cayenne, ground	oz.	1
Pills of camphor (grains two) and opium (grain one)	no.	300
Pills, cathartic compound	no.	600
Pills of compound extract of colocynth (grains three) and ipecacuanha (grain one-half)	no.	600
Pills of ipecacuanha, powdered, and opium (grains, five)	no.	400
Pills of mercury (blue mass)	no.	500
Pills of opium	no.	700
Pills of sulphate of quinia (grains three)	no.	500
Quinia, sulphate of, compressed	oz.	2
Silver, nitrate of, fused	oz.	1
Soap	oz.	4
Turpentine, oil of	oz.	6
Zinc, sulphate of	oz.	2

HOSPITAL STORES.

Beef, extract of, Liebig's	lb.	1
Candles, composition, half length	lb.	½
Milk, concentrated	lb.	1
Sugar, white	oz.	16
Tea, black	oz.	8
Whisky	oz.	24

INSTRUMENTS.

Cupping tins	no.	4
Probang	no.	1
Scissors	pair.	1
Syringes, penis, glass	no.	4
Syringe, self-injecting	no.	1
Tourniquets, field	no.	2

DRESSINGS, &c.

Bandages, roller, unbleached and unsized:		
6—1 inch by 1 yard long. 12—2 inches by 3 yards long. 12—2½ inches by 3 yards long. 4—3 inches by 4 yards long. 1—3½ inches by 5 yards long. 1—4 inches by 8 yards long.	doz.	3
Felt	pieces.	8
Lint, patent	lb.	½
Matches	box.	1
Muslin, unbleached, unsized, one-yard wide	yds.	3
Needles, cotton, thimble, in case	no.	1
Oiled silk	yd.	⅛
Pencils, hair, in vial	no.	6
Pins	paper.	1
Plaster:		
Adhesive, in tin can	yds.	2
Isinglass	yds.	2
Silk, ligature	oz.	¼
Sponge, fine, small pieces	no.	4
Tape, pieces	no.	2
Tow	lb.	1
Towels	no.	3

BOOKS, STATIONERY, ETC.		
Envelopes, printed, letter size	no.	25
Inkstand, traveler's, filled	no.	1
Morning Report Book, Regiment	no.	1
Paper, letter, ruled	qrs.	2
Pencils, lead	no	2
Penholders	no.	2
Pens, steel	no.	12
Register of patients, small, flexible covers	no.	1
Tray, tin, for books and stationery	no.	1
MISCELLANEOUS.		
Basins, tin, small, for dressers	no.	1
Plates, for dressers	no.	1
Candle-holder	no.	1
Corks	doz.	2
Corkscrew	no.	1
Measure, graduated, glass:		
2 oz	no.	1
Minim	no.	1
Medicine measuring glass, in case	no.	1
Mortar and pestle	no.	1
Pill boxes	paper.	½
Scales and weights, prescription	set.	1
Spatula, 3 inch	no.	1
Spoon, tea	no.	1
Vials:		
2—4 ounce, 2—2 ounce, 2—1 ounce	no.	6

No. 3. Two specimens of hospital knapsack, containing dressings, and designed to be carried by an orderly accompanying a medical officer; used during the war of 1861–'65. From the Army Medical Museum. (No. 4444, xxviii, B. *b.* 4.)

No. 4. A pair of saddle-bags, containing medical and surgical supplies, of the pattern used in the Russian army. Presented by the Russian Government to the Army Medical Museum. (No. 57, 6, xxviii B. *b.* 15.)

No. 5. A hospital knapsack of the pattern used by the Russian army. Presented by the Russian Government to the Army Medical Museum. (No. 5717, xxviii, B. *b.* 16.)

This room also contained the three chests belonging to the new army medical transport cart. (See description of cart below.)

Room No. 10.

This room contained samples of litters and stretchers, &c., viz:

No. 1. Two cacolets, French pattern, designed to be fastened to a pack-saddle on a horse or mule, for the transportation of wounded.

No. 2. Wheeled litter, patented August 7, 1866, by Colonel Tompkins, U. S. A.

No. 3. Mule litter for the transportation of wounded, designed by assistant Surgeon Henry McElderry, U. S. A., and actually used during the Modoc campaign.

No. 4. Mule litter; designed to be carried between two mules or horses.

No. 5. Four patterns of hand litters used during the war of 1861–'65.

No. 6. Two hand litters on springs; designed to carry the wounded in an ordinary wagon. Made by Col. P. V. Hagner, Watervliet Arsenal.

No. 7. Apparatus for fracture of the thigh; designed to facilitate the comfortable transportation of such patients (two pieces of apparatus with a photograph). By Surgeon J. Sanger, U. S. V.

No. 8. Four photographs of an ambulance; designed by the same gentleman.

On the walls were the following photographs from the surgical section of the Army Medical Museum:

1. Dr. Schronborn's excision of the head of the femur.

2. Assistant Surgeon J. R. Gibson's case of excision of the head of the femur.

No. 3. The same, with the apparatus applied.

In the lower panes of the window of the same room were two transparencies from photographs made at the Army Medical Museum by Assistant Surgeon J. J. Woodward, U. S. A., viz: (*a*) Small vein in urinary bladder of frog; magnified 800 diameters. (*b*) Small artery from mesentery of frog; magnified 1,000 diameters.

Room No. 11.

This room was fitted up as a sitting-room for physicians visiting the hospital who desired to examine at leisure the publications of the Surgeon-General's Office, photomicrographs, and microscopial specimens from the Army Medical Museum. It contained a microscope, &c., for their convenience. The lower panes of the window contained transparencies from photographs made at the Army Medical Museum by Assistant Surgeon J. J. Woodward, U. S. A., viz: (*a*) Terminature of nerves; involuntary muscle, magnified 800 diameters. (*b*) Eye of beetle; magnified 800 diameters.

SECOND STORY—HALL WAY.

The lower panes of the windows of the halls of this floor contained transparencies from photographs made at the Army Medical Museum by Assistant Surgeon J. J. Woodward, U. S. A., viz:

No. 1. (*a*) Small artery and capillaries in urinary bladder of frog; magnified 800 diameters. (*b*) The same; magnified 2,000 diameters.

No. 2. (*a*) Stomata between the epithelial cells of a small vein in the mesentery of a frog; magnified 800 diameters. (*b*) Small vein from urinary bladder of frog; magnified 2,000 diameters.

GROUNDS IN THE REAR OF THE HOSPITAL.

The hospital tents and full-sized medicine wagons, cart, and ambulances were placed in the grounds immediately behind the hospital.

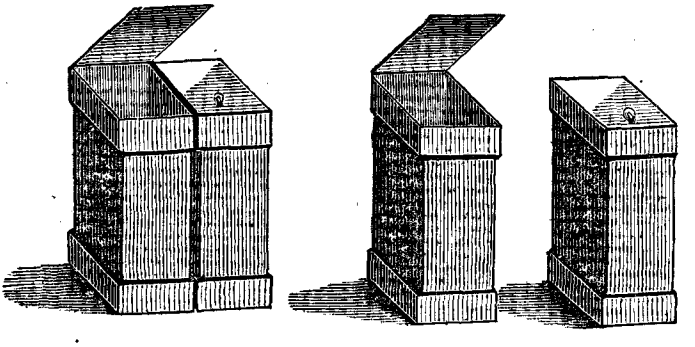
No. 1. The hospital tents. The field hospitals of the moving armies during the war 1861-'65 were usually constructed of hospital tents. In the most general arrangement, three hospital tents pitched end to end constituted the unit, by the repetition of which these hospitals were extended to the necessary capacity. Hospital tents were also largely used to provide additional accommodations in connection with the great general hospitals. In this case four hospital tents pitched end to end very often constituted the unit, and a wooden floor was frequently provided.

The hospital tents thus used were of the regulation pattern used by the Medical Department in time of peace, and were each 15 by 14 feet. Three of them were pitched end to end in the manner used during the war in the rear of ward No. 2 of the hospital.

No. 2. Perot & Co.'s improved United States Army medicine wagon. The firm of Perot & Co. made a large number of medicine wagons for the Medical Department during the war of 1861–'65. In most of these the fixtures were arranged in a large wagon intended to be drawn by four or six mules, which differed from the ordinary Army wagon chiefly in being furnished with springs. As this wagon proved to be too heavy, the manufacturers designed a much lighter vehicle. It was drawn by two horses, and was found in practice very convenient. The following description has been furnished by the manufacturers:

The fixtures are composed of four boxes—two on top of each other facing towards the front of the wagon and two towards the back. These boxes occupy only a little more than one-half of the wagon, leaving the balance of the room for any necessary purpose. The amputating table has a perfectly immovable catch to fasten the legs. By this arrangement the table is put up in a very short time, and is perfectly steady; it is very strong, the top being composed of plank 6½ feet long, 2¼ feet wide, and 1½ inches thick. This table is placed entirely out of the way, under the body of the wagon, instead of inside on the bottom, as in our old pattern.

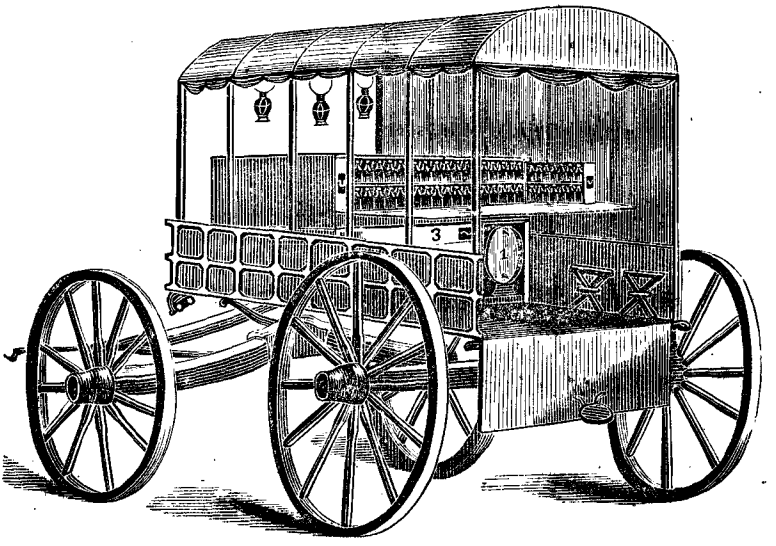
MODE OF PACKING BOTTLES.



The above cut represents the form of our pasteboard boxes for packing the bottles. It will be observed that each box has a flange on top and bottom, and when they come together they can only touch on the flanges, leaving a column of air between them; with these boxes placed side by side in a drawer or box there is no danger of breakage. An ambulance officer, in charge of one of our original wagons, has informed us that his wagon overturned into a ravine, from 14 to 16 feet deep, without a bottle being broken. Another wagon fell 8 feet with the same result. The general features and mode of packing in the new form of wagon do not differ from the old one.

The preceding cut represents a back view of the wagon, with the tail-board down, showing a vacant space inside, about 3½ feet wide and 4 feet long, with the two hind boxes fronting into this space. The lower box contains the closet No. 1, holding the whiskey keg. Nos. 2 and 3 are two drawers, and No. 4 is a small closet for a can of alcohol. The upper box or dispensing case contains two drawers, Nos. 4 and 5, and over them the dispensing apartment, of which a view is given, the operator occupying a camp stool in the vacant space in the wagon. This differs from our old wagon, as

BACK VIEW OF MEDICINE WAGON.

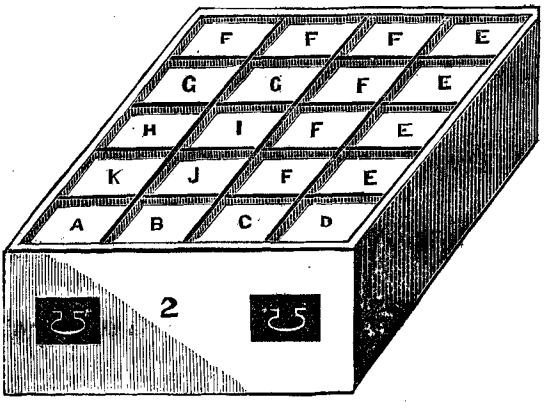


in it the door was in the side instead of the back, and the vacant space, which was only about half as large as in the new one, was in the center. Below we give the diagrams and contents of the drawers, &c., fronting towards the back.

No. 1

Is a locked closet occupying one side of the lower box, containing an oval keg for 6 galls. of whiskey, with a cock on top and bottom, one to let air in, the other to draw from. This keg is on skids, and can be drawn out, and filled at the bung.

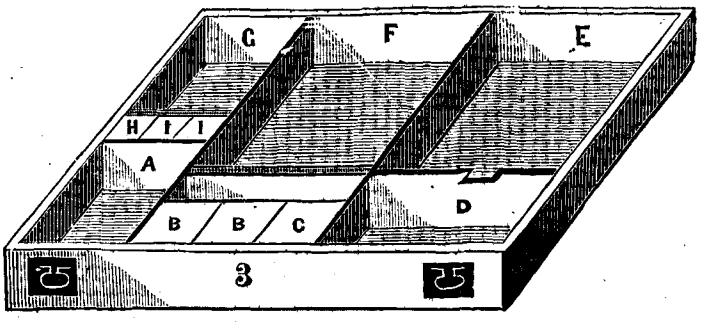
No. 2. DRAWER.



Contents of Drawer No. 2.

A. Thirty-two oz. stronger ether, for anæsthesia.
B. Thirty-two oz. sweet spirit of nitre.
C. Thirty-two oz, solution of ammonia.
D. One qt. bottle oil of turpentine.
E. Four qt. bottles castor oil.
F. Six qt. bottles brandy.
G. Two qt. bottles olive oil.
H. Thirty-two oz. purified chloroform.
I. Thirty-two oz. copaiba.
J. Ten oz. sulphate of quinia.
K. Four lb. sirup of squill (part in Drawer No. 9).

No. 3.—DRAWER.



Contents of Drawer No. 3.

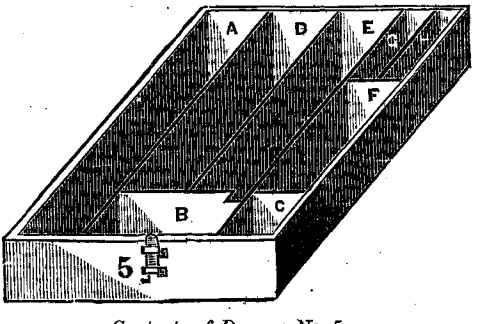
A. One sponge-holder, for the throat.
A. Twelve probangs.
A. One tongue-depressor, hinged.
A. Four trusses, single.
B. Two bottles ink.
C. One bottle mucilage.
D. One U. S. Dispensatory.
E. One portfolio, cap size.
E. Two blank books, quarto.
E. One order and letter book.
E. Four quires writing paper.
E. One register of patients, small, flexible cover.
F. One copy Gray's Anatomy.
F. One copy Erichsen's Surgery.
F. One copy Minor Surgery, Packard's.
F. One case book.
F. One copy Gunshot Wounds, Longmore.
G. One tooth-extracting case, army pattern.
G. One hard-rubber syringe, 8 ounce.
G. One rubber syringe, self-injecting.
H. Two thumb-lancets.
H. Twelve hair pencils.
I. Two scarificators.

No. 4.

Contents of No. 4.

A locked closet on one side of the box which contains a can for 3 gallons of alcohol, and a vacant drawer for any articles desired.

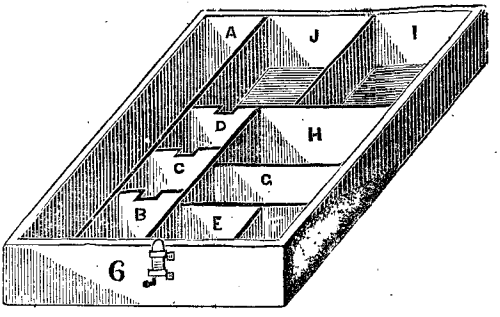
No. 5.—DRAWER IN DISPENSING CASE.



Contents of Drawer No. 5.

A, D, and E. One set splints, 6 for forearm, 4 for leg, 6 large coaptation, 4 small coaptation.
B. Two papers pill boxes, turned wood.
C. One pair pliers.
C. One gimlet.
C. One tape-measure.
D. Eight pieces binder's boards, 4 by 17 inches.
E. Eight pieces binder's bds., 2½ by 12 in.
E. Razor strop, in case.
E. One file.
F. Six penis syringes, glass.
F. One corkscrew.
F. One set Aiken's tool pad.
G. Eight oz. twine, ¼ coarse.
H. One hone.
H. One razor.

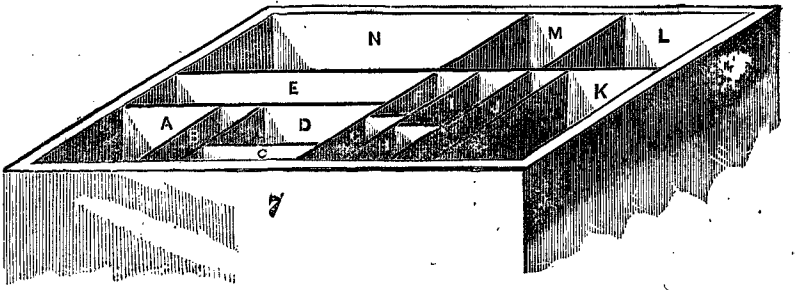
No. 6.—Drawer in Dispensing Case.



Contents of Drawer No. 6.

A. Two quires wrapping-paper; white and blue.
B. Two oz. ligature silk.
B. One oz. linen thread, unbleached.
C. Two papers pins.
C. Four pieces cotton tape.
D. Case containing 25 needles, 1 spool of cotton, and thimble.
D. One yard gray silk, for shades.
E. Eight field tourniquets.
E. Two screw torniquets, with pad.
F. Twelve cupping tins.
G. Two scissors (large and small).
G. One pocket case.
H. *Vacant for sundries.*
I. One hundred printed envelopes.
I. One traveler's inkstand.
I. Twenty-four steel pens.
I. Two penholders.
I. Six lead pencils, No. 2.
I. One stick sealing-wax.
J. One sheep-skin, dressed.

No. 7.—Dispensing Case.



This is an inside view of the case, with the dispensing department in front, closed.

Contents of Dispensing Case.

A. One Wedgewood mortar.
B. Two dozen vials, six 6-oz., twelve 4-oz., three 2-oz., three 1-oz.
C. One pill tile, 6 by 8 inches.
D. Eight oz. fine sponge, small pieces.
D. One tin funnel, pint.
E. Five yards adhesive plaster.
E. Four lb. patent lint.
E. Pestle for mortar.
F. Four yards red flannel, all wool.
F. Two medicine measuring glasses.
G. Two yards gutta-percha cloth.
G. Five yards isinglass plaster.
H. Eight doz. assorted corks.
H. One glass graduated measure, 4-oz.
H. One minim measure.
I. Ten yards bleached muslin.
J. Two cotton bats.

J. One sheet cotton wadding.
J. One set prescription scales and weights.
K. Two spatulas, 3 and 6 inch.
K. Two glass urinals.
L. Eight suspensory bandages.
L. Two lb. scraped or picked lint.
L. Two and one-quarter yards oiled silk.
L. Two and one-quarter yards oiled muslin.
M. Sixteen dozen roller bandages, assorted. Two doz. 1 inch by 1 yard; four doz. 2 inches by 3 yards; four doz. 2½ inches by 3 yards; two doz. 3 inches by 4 yards; two doz. 3½ inches by 5 yards; one doz. 4 inches by 6 yards; one doz. 4 inches by 8 yards.
N. Ten lb. pressed tow.
N. One doz. towels.

Articles in dispensing apartment.

In the front.

Aromatic sulphuric acid.
Tannic acid.
Spirit of nitrous ether (sweet spirits of nitre).
Stronger ether, for anæsthesia.
Strong alcohol.
Olive oil.
Castor oil.
Tincture of opium (laudanum).
Camphorated tincture of opium.
Acetate of lead.
Bicarbonate of potassa.
Creasote.
Fluid-extract of colchicum seed.
Fluid-extract of aconite root.
Fluid-extract of ipecacuanha.
Fluid-extract of seneka.
Tincture of the chloride of iron.

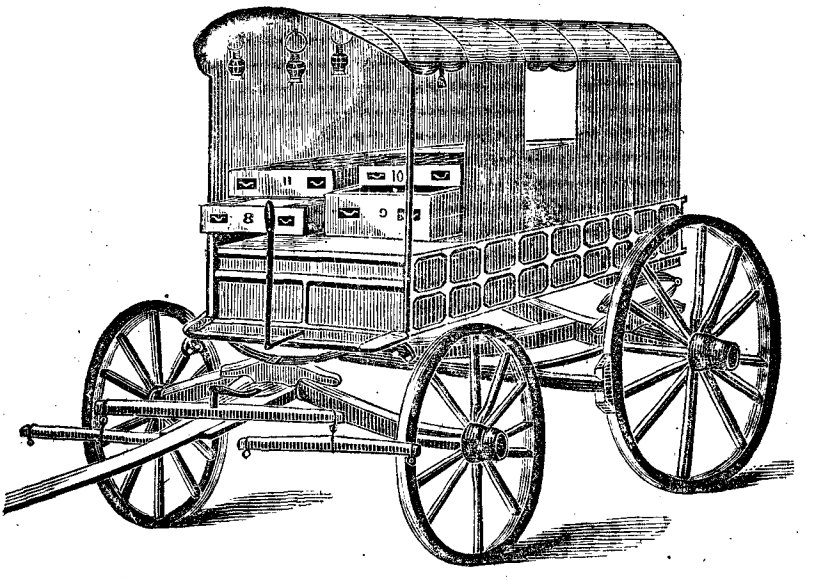
In right-hand side.

Comp. spt. of ether (Hoffman's anodyne).
Carbonate of ammonia.
Solution of ammonia.
Camphor.
Collodion.
Copaiba.
Sulphate of copper.
Alcoholic extract of belladonna.
Fluid-extract of cinchona (aromatic).
Fluid-extract of ginger.
Mercury with chalk.
Oil of turpentine.
Croton oil.
Permanganate of potassa.
Solution of arsenite of potassa (Fowler's solution).
Chlorinated solution of soda.
Solution of chloride of zinc.
Resin cerate.
Simple cerate.
Sulphate of alumina and potassa (alum).
Aromatic spirits of ammonia.
Purified chloroform.
Compound powder of opium (Dover's powder).
Sulphate of morphia.
Solution of the subsulphate of iron.
Pure glycerine.
Chlorate of potassa.
Iodide of potassium.
Bicarbonate of soda.
Whiskey.
Sirup of squill.
Pills of mercury (blue-mass).
Ointment of the nitrate of mercury (citrine ointment).
Powdered squill.

In left-hand side.

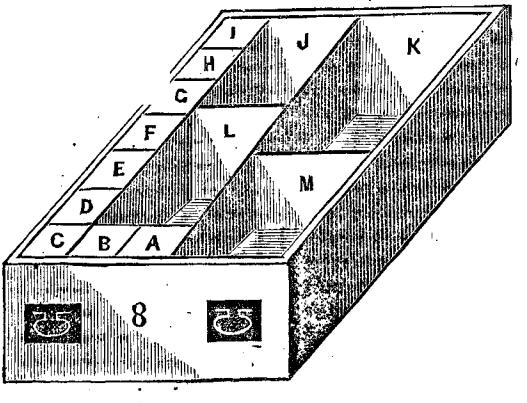
Powdered gum-arabic.
Nitrate of silver, in crystals.
Fused nitrate of silver.
Sulphate of cinchona.
Citrate of iron and quinia.
Powder of subsulphate of iron.
Iodide of iron.
Powdered ipecacuanha.
Powdered opium.
Pills of camphor (2 grains) and opium (1 grain).
Compound cathartic pills.
Opium pills.
Pills of sulphate of quinia (3 grains).
Sulphate of quinia.
Powdered Rochelle salt.
Sulphate of zinc.
Blistering cerate.
Powdered compound extract of colocynth.

FRONT VIEW OF MEDICAL WAGON.



The preceding cut represents a front view of the wagon. Inside of the wagon, attached to the second bow, hang from the top three box-lanterns, always ready for use. Of the two front boxes the lower is large and contains no drawers or partitions, and is used for holding the bed-covers, pillow-ticks, and such articles. The lid of this box forms the driver's seat; the upper box recedes about 14 inches and forms a back for the driver. This box contains four drawers, as follows:

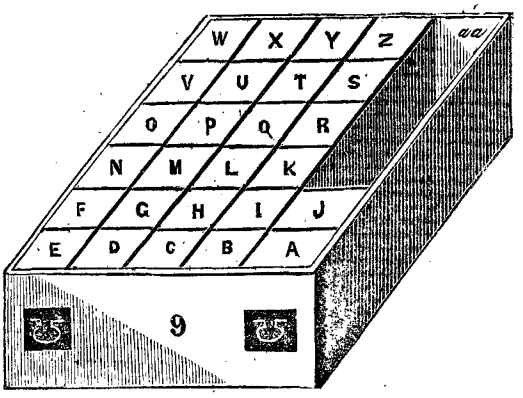
NO. 8.—DRAWER.



Contents of Drawer No. 8.

A. Eight oz. solution of arsenite of potassa (Fowler's solution).
B. Eight oz. aromatic sulphuric acid.
C. Eight oz. fluid-extract of ipecacuanha.
D. Eight oz. fluid-extract of seneka.
E. Eight oz. tincture of the chloride of iron.
F. Eight oz. pure glycerine.
G. Pill of mercury (blue-mass).
H and I. *Empty bottles.*
J. Eight lb. sulphate of magnesia.
K. Eight lb. flaxseed meal.
L. Ten lb. farina.
M. Twelve lb. white crushed sugar.

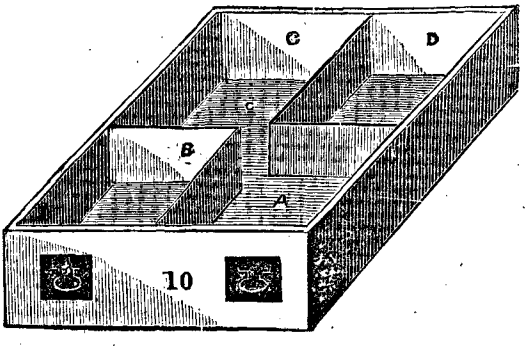
No. 9.—DRAWER.



Contents of Drawer No. 9.

A. Sixteen oz. compound spirits of ether (Hoffman's anodyne).
B. Sixteen oz. fluid extract of ginger.
C. Sixteen oz. tincture of opium (laudanum).
D. Sixteen oz. camphorated tincture of opium.
E. Sixteen oz. chlorinated solution of soda.
F. Sixteen oz. solution of chloride of zinc.
G. Four lb. sirup of squill (part in drawer No. 2).
H. Eight oz. tartaric acid, powdered.
I. Sixteen oz. subnitrate of bismuth.
J. Eight oz. ground cayenne pepper.
K. Sixteen oz. powdered Rochelle salt.
L. Eight oz. sulphate of alumina and potassa.
M. Eight oz. mercury with chalk.
N. Eight oz. powdered ipecacuanha.
O. Eight oz. compound powder of opium (Dover's powder).
P. Eight oz. acetate of lead.
Q. Eight oz. bicarbonate of potassa.
R. Eight oz. chlorate of potassa.
S. Eight oz. iodide of potassium.
T. Eight oz. bicarbonate of soda.
U. Eight oz. nutmegs.
V. Eight oz. powdered gum-arabic.
W. Eight oz. carbonate of ammonia.
X. Eight oz. camphor.
Y. Eight oz. powered opium.
Z. *Empty bottles.*
a. a. Eight lb. Castile soap.

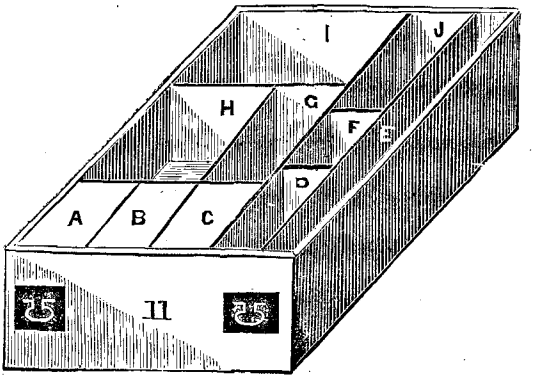
No. 10.—DRAWER.



Contents of Drawer No. 10.

A. Two tin basins, small, for dressers.
A. Three wash-hand basins.
B. *Vacant for sundries.*
C. One metal bed-pan.
D. *Vacant for sundries.*

No. 11.—DRAWER.



Contents of Drawer No. 11.

A. Three lb. simple cerate.
B. Twenty-four oz. sulphate of cinchona.
C. Sixteen oz. mercurial ointment.
D. One smoothing plane.
E. One saw.
E. One hatchet.
E. One nutmeg grater.
F. Four oz. white wax.
G. Six lb. ground black-
H. Five lb. black tea.
I. *Vacant for sundries.*
J. Two lb. candles, half length.

No. 12.

Box used as the driver's seat, and contains:

Two doz. planed splints.
Twenty gray blankets.
Two blanket cases, canvas.
Eight gutta-percha bed-covers.
Fifteen bed-sacks.
Fifteen pillow-cases, white.
Two leather buckets.
One coffee-mill.

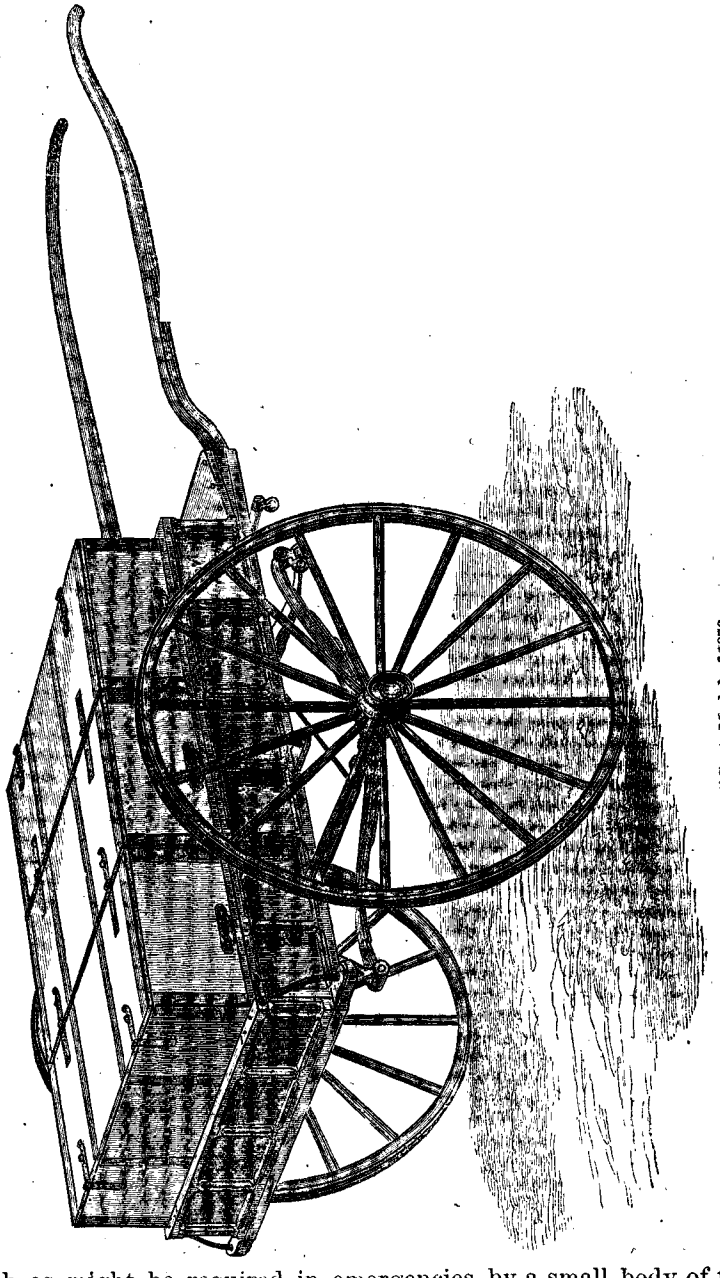
Strapped on the inside of the wagon are two camp-stools. On hooks attached to one of the wagon-bows are three lanterns. On the outside are four hand-litters. Under the wagon is an amputating table.

No. 3. United States Army medicine wagon, Autenveith's pattern. In this medicine wagon two large chests, containing the fixtures and supplies, are carried in an ordinary army wagon. A considerable number of wagons of this pattern were used during the war of 1861–'65, the chief objection to them being their great weight, which rendered four or six mules necessary to draw them.

No. 4. United States Army medical transport cart, model of 1876.

DESCRIPTION.—The principal means of transport for field medical and hospital supplies employed in the Union armies in the late civil war were the ordinary wagons of the supply trains, ambulance wagons, the medicine wagons of Perot and of Dunton, the regulation army medicine wagons, and panniers designed for transport by pack-animals, but usually carried by the most available wheeled vehicles. For the last ten years, field parties of troops engaged in hostile operations against the savages of the plains, or of the mountainous western region, have carried their medical supplies either in the regulation medicine wagons,

drawn by six mules, or in chests or panniers, placed in the ordinary wagons of the supply train. The necessity of some convenient means for the rapid transport of a limited supply of medical and hospital stores,



U. S. A. Medical Transport Cart, Model of 1876.

such as might be required in emergencies by a small body of troops, became apparent. Scouting parties and escorts to exploring or surveying expeditions required an outfit of hospital appliances for immediate

use, yet could not be encumbered with the large medicine wagons that carried supplies for brigades.

Under these circumstances, recalling that Paragraph 1330 of the Army Regulations permitted the provision of "two-wheeled transport carts for hospital supplies" for small commands,* although the provision had never been carried into effect, the exigencies of the late war having demanded more bulky means of transport, the Surgeon-General decided to have built an experimental one-horse, two-wheeled, medical transport vehicle, to serve, if it should prove satisfactory, as a model for the construction of others, for issue to troops likely to be engaged in the field. This proposition having been approved by the Secretary of War, the Surgeon-General indicated certain indispensable requisites to be observed in regard to the dimensions, weight, and strength of the proposed vehicle, and instructed Assistant Surgeon G. A. Otis, the medical officer on duty with a Board of Officers convened to recommend a pattern of ambulance wagon for Army use, to confer with the commandant of Watervliet Arsenal, Bvt. Brig. Gen. P. V. Hagner, Ordnance Department, and to prepare specifications for such a hospital transport cart. The specifications submitted were as follows:

MEDICAL TRANSPORT CART.

REQUISITES.

1st. To be large enough to carry three (3) boxes for stores, each 18 inches wide, 36 inches long, and 18 inches high.

2d. The weight of the finished cart, with wheels and empty boxes, must not exceed 600 pounds, and have strength of frame sufficient to withstand a load of 800 pounds.

3d. The cart-wheels must be interchangeable with the hind wheels of the new ambulance wagon.

SPECIFICATIONS.

Wheels.—The wheels will be 4 feet 2 inches high (without tires); the hubs (of best elm) 6½ inches in diameter at center, 5½ inches at butt, and 4½ inches at the point, by 9 inches in length; butt with iron bands on each end mortised for sixteen (16) spokes. Size of mortise 1⅝ inches by 9-16 inch with a ⅜-inch dish. Spokes (best seasoned hickory) 1½ inches by ⅝ inch (hub tenon) felloe tenon, round, ¾ inch in diameter; felloes (best hickory) 1⅝ inches, two (2) pieces for each wheel; tire (best charcoal iron) 1½ inches wide, by ⅝ inch thick, fastened on with eight (8) tire-bolts in each wheel; two (2) felloe-plates in each wheel over joints.

Axle.—Of best quality refined iron 1½ inches square for 7 inches from each collar-washer, the remainder rounded. Collar-washer 2⅝ inches in diameter, ⅝ inch thick; wheel-boxes of best quality foundry iron, 7½ inches long, 1½ inches in diameter, 7-16 inch thick at butt; 1⅝ inches in diameter, and 5-16 inch thick at point, with two (2) lugs, 2 inches long, ½ inch high. Oil-chamber, 2 inches long, 1-16 inch deep, to commence 2½ inches from the butt. Weight of box, not less than 4¾ lbs. each. Axle to be arranged to track five feet from center to center of wheels.

Body.—Outside length 57⅛ inches, width 40¼ inches, height 8 inches. Inside length 54⅞ inches, width 38 inches, height 6 inches. Frame, of oak, consisting of two (2) ex-

**United States Army Regulations of* 1861, with an Appendix, containing the Changes and Laws affecting Army Regulations and Articles of War to June 25, 1863, Washington, 1863, p. 317.

terior side-sills and two (2) end cross-bars, size 1¼ by 2½ inches. Center cross-bar 2 inches by ⅝ inch, and two (2) interior cross-bars, at half distance between the center and the ends, 2 inches by ⅝ inch; all cross-bars, except the tail-bar, are mortised into the side-sills, and are even with them at bottom; the tail-bar is mortised to receive the sill-tenons. The tenons of the end bars are of one-third thickness; those of the interior bars are of half the thickness. The floor planks will be ash, ½ inch thick, and level with the top of the side-sills. The upper rails are 1⅛ inches by 1 inch, and extend over the sides and front, and are vertical. The side panels of the body are of ash, screwed, each side, to six (6) single studs and to a front double corner stud; the front panel of the body, also of ash ½ inch thick, is screwed, in like manner, to three (3) single studs and the double corner studs, to which the sides are attached. These studs are all tenoned into the side-sills and upper rails. The studs are 5 inches long; the single ones ⅝ inch by 1 inch, and chamfered at their exterior corners between the sill and upper rail. The double corner studs are made from square pieces 1⅛ by 1⅛ inches. The sides and front of the body are stayed by upright rods and flat angle-irons about the front corners and the sides, also, by upright and brace rods at the rear. The ends of the rear cross-bar and the center-bar project 4½ inches beyond each side to receive lower ends of these braces. The tail-board is framed of ⅝ inch (panel) boards of ash, screwed to five (5) studs ⅝ by 1 inch, mortised into a top and bottom rail 1 inch by 1½ inches. The length of tail-board extends even with the exterior of the sides. The tail-board will be hung to the rear cross-bar by three light hinges, to stand even with the end of bar when upright, and will be held closed by means of hooks attached to the sides, and hooking into eyes attached to the irons on the upper rail of the tail-board.

Springs.—Two (2) side half-springs, perpendicular to the axle, and clipped beneath it, connected in front by a cross-spring. The side-springs are to be 48 inches long, of English No. 3 oil-tempered steel, of five (5) leaves, 2 inches wide. The cross-spring, of the same number of leaves, of the same width and thickness and 38 inches long, or of sufficient length to connect the side-springs. The eye will be of double thickness, and have eye-bolts, 7-16 of an inch. The spread of the springs should be as slight as will keep the body off the axle. The cross-spring will be bolted to an iron cross-piece, which is bolted to the shafts and side-sills. The side-springs will be clipped beneath the axle, by pairs of clips, screwed by nuts, with brass spring-blocks. Behind, the side-springs will be bolted to the sills by iron V-pieces, as may be found most convenient. India-rubber buffers may be interposed over the clips of the side-springs to the axle.

The *shafts* are made of ash, 1⅝ by 2¼ inches, separated 22 inches in front, and 30½ inches at the foot-board. They will be somewhat curved, so as to carry the body nearly level, or with a slight inclination downwards at the rear. They are bolted to the body through the front cross-bar and the forward interior bars, being also locked by mortises 1½ inches deep at each bolt. A foot-board 4 feet long 8 inches wide and 1 inch thick, of oak, is bolted to the top of the side-sills, which extend 8 inches in front of the body, to receive the foot-board. The bolts also pass through triangular blocks placed between the foot-board and the sills, and also on the shafts, which give a suitable inclination to the board.

Swingle-tree and splinter-bar.—The draft is made from the axle by means of two (2) wrought-iron rods ½ inch in diameter, bolted under the foot-board to an oaken splinter-bar, to which the swingle-tree is attached. The swingle-tree will conform to that used in the ambulance wagon.

Chests.—There will be three (3) chests, interchangeable, and consequently of uniform dimensions, viz, 36 inches long, 18 inches wide, 18 inches high. They will be made of half-inch boards of walnut or ash, and firmly framed, and secured against splits or strains by light steel straps and angle braces. The bottoms of the boxes will be covered with sheet zinc and the tops by cow-hide. The under corners will be supplied with strong casters, and at the middle of each end there will be strong

iron folding-handles, which must not project more than half an inch when folded down. The chests will open from above by hinged lids, and will be secured, each, by two suitable bolts and locks equidistant from either end.

Slide-board.—A slide-board, to lower the boxes from the cart to the ground, will be carried on iron loops attached underneath the body, so that when drawn to the rear, to be used as a slide, the hooks at the front end will hold by the rear loops, and when not wanted for use this board will slide back on its loop, and be secured by a thumb-screw.

Tarpaulin.—A canvas cover, about 6½ by 5 feet, will be provided with eyelets at the four corners, to be secured to suitable adjustable fastenings to the four corner studs.

Painting.—The cart will be painted of the color and finish of caissons and other ordnance carriages, the iron work black. The letters "U. S.," 4 inches high, will be painted at the center of each side panel. Near the front end of each side panel a stencil mark will be placed with the inscription, in small characters,

Transport Cart U. S. A. Med. Dept.

The cart was constructed in accordance with the foregoing specifications, at Watervliet Arsenal, West Troy, under the direction of Bvt. Brig. Gen. P. V. Hagner, U. S. A., and was delivered at the Surgeon-General's Office, in Washington, January 15, 1876, and inspected and approved.

It remained that the three chests, designed to contain respectively surgical instruments and appliances, medicines and hospital stores, mess furniture and utensils, should receive their outfit.

By direction of the Surgeon-General, the fitting up and furnishing of the medicine and mess chests belonging to the medical transport cart has been intrusted to Assistant Surgeon D. L. Huntington, U. S. A. In carrying out this work, the endeavor has been made to select from the standard supply table of the Medical Department such medicines, stores, appliances, and utensils as experience has proved to be useful and necessary for the ordinary emergencies of field service, and to arrange them compactly and conveniently.

As the Supply Table has been strictly conformed to in the preparation of the list for furnishing these chests, it will be possible to refurnish them from the stores usually found at even the more remote frontier posts. Under the circumstances ordinarily attendant upon scouts, expeditions, and marches, it is believed that the quantity and variety of the supply furnished will be abundantly adequate for a force of not less than five hundred troops for a period of three months. The medicine chest has been divided by means of accurately fitting trays into five divisions, the trays subdivided into spaces and compartments for the disposal of medicines, appliances, &c., and, so far as possible, these spaces and compartments have been constructed with reference to the average size and form of the original package or article furnished for the Medical Department, so that the chest may be readily and quickly filled from any dispensary.

Medicine chest.—The medicine chest is furnished with five trays cov-

ered by accurately fitting lids. The trays are of black walnut and are 17½ inches long, 16¾ inches wide, and vary in depth and in their subdivisions.

All the trays are readily raised by apertures for the fingers cut near the upper edges of the ends and not represented in the cuts.

Tray No. 1 is 5 inches in depth and is subdivided into three compartments as indicated in the accompanying cut (Fig. 2). One compartment is intended for stationery, the two others for miscellaneous articles, as enumerated in the subjoined list:

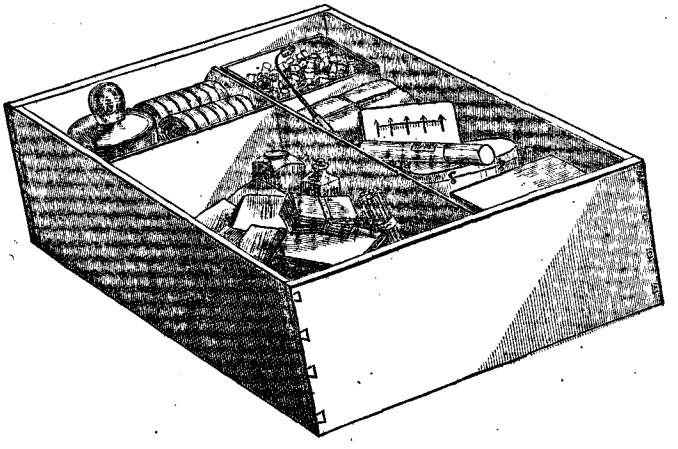


FIG. 2.—Tray No. 1 of medicine chest.

Compartment A contains—

Paper, cap, ruled, quire 1.
Paper, quarto-post, ruled, quire 1.
Paper, note, ruled, quire 1.
Envelopes, official, large, No. 25.
Envelopes, official, small, No. 25.
Inkstand, traveler's, filled, No. 1.
Pencil, lead, Faber's, No. 2, No. 6.
Pens, Gillott's steel, No. 12.
Penholders, No. 6.
Ink, carmine, bottles, 1.
Mucilage, bottles, 1.
Elastic rubber-bands, doz. 1.
Pocket register for patients, No. 1.

Compartment B contains—

Pill tile, 8 by 6, No. 1.
Probang, No. 1.
Ichthyocolla plaster, in case, yards 1.
Fountain syringe, in case, No. 1.
Assorted corks, box 1.
Pill boxes, paper, No. 1.
Matches, in tin box, boxes 1.

Compartment C contains—

Brass spirit lamp, with wicking, No. 1.
Hard rubber penis syringe, No. 1.
Tape measure, No. 1.
Suspensory bandages, No. 6.
Needle-case, filled, No. 1.
Pins, papers 1.
Tape, roll 1.

Tray No. 2, of the same dimensions as tray No. 1, is subdivided into forty-one compartments as indicated in the annexed wood-cut (Fig. 3,)

and is intended for medicines and such pharmaceutical appliances as are necessary to fit out a temporary dispensary for the field.

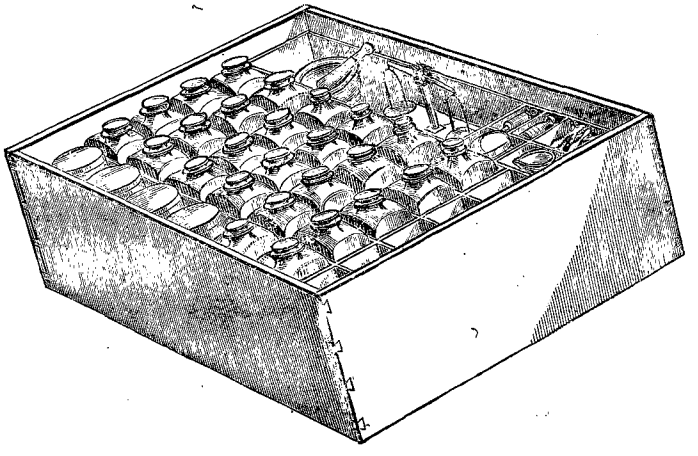


FIG. 3.—Tray No. 2 of medicine chest.

This tray contains—

Extractum hyoscyami, in 1 oz. pots, oz. 2.
Extractum conii, in 1 oz. pots, oz. 2.
Extractum belladonnæ, in 1 oz. pots, oz. 2.
Sodæ bicarbonas, oz. 6.
Ipecacuanhæ pulvis, oz. 4.
Pilulæ extracti colocynth, Comp. (gr. iii) et ipecacuanhæ, gr. ss. } No. 500.
Pilulæ catharticæ compositæ, No. 600.
Pilulæ opii, No. 500.
Pilulæ opii camphoræ, No. 500.
Pilulæ quiniæ sulphatis (3 grains each) No. 600.
Pilulæ hydrargyri, oz. 8.
Acidum tannicum, oz. 4.
Calomel.
Acidum salicylicum, oz. 4.
Chloral hydrate, oz. 4.
Rhei pulvis, oz. 4.
Acaciæ pulvis, oz. 4.
Plumbi acetas, oz. 4.
Potassæ permanganas, oz. 4.
Zinci sulphas, oz. 2.
Zinci oxidum, oz. 4.
Morphiæ sulphas, oz. ¼.
Cupri sulphas, oz. 1.
Argenti nitras (fused), oz. 1.
Bismuthi subnitras, oz. 4.
Collodion, oz. 2.
Glycerina, oz. 4.
Ferri perchloridum, oz. 1.
Tinctura catechu, oz. 4.
Porcelain table, and teaspoon, No. 1.
Minim glass, No. 1.
Hypodermic syringe, No. 1.
Prescription scales and weights in case No. 1.
Mortar and pestle, Wedgewood, 3 inch, No. 1.
Spatulæ (large and small), No. 2.
Stethoscope, No. 1.
Scarificator, No. 1.
Scissors, No. 1.
Medicine glass and case, No. 1.
Corkscrew, No. 1.

The small half spaces, represented as unoccupied in the cut (Fig. 3), are left for the convenience of packing any small articles which may be considered of importance.

Tray No. 3 is 6 inches in depth, the other dimensions are similar to the preceding. The bottles used in both trays are 8, 4, and 2 ounce tincture and saltmouths.

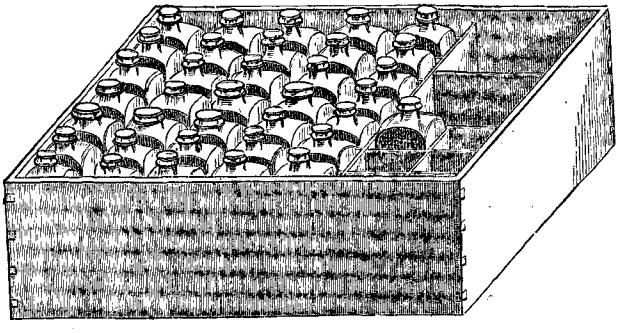


FIG. 4.—Tray No. 3 of medicine chest.

This tray contains—

Linimentum (as per Standard Supply Table), oz. 8.
Aquæ ammoniæ, oz. 8.
Spiritus ætheris nitrici, oz. 8.
Tinctura ferri chloridi, oz. 8.
Extractum gentianæ fluidum, oz. 8.
Tinctura opii, oz. 8.
Chloroformum, oz. 8.
Oleum terrebinthinæ, oz. 8.
Tinctura opii camphorata, oz. 8.
Oleum ricini, oz. 8.
Spiritus ammoniæ aromaticus, oz. 8.
Extractum zingiberis fluidum, oz. 8.
Cough mixture (per Standard Supply Table), oz. 8.
Tinctura aconiti radicis, oz. 8.
Potassæ chloras, oz. 8.
Potassii bromidum, oz. 8.
Potassii iodidum, oz. 8.
Pulvis ipecacuanhæ et opii, oz. 8.
Quiniæ sulphas, oz. 8.
Extractum ergotæ fluidum, oz. 4.
Extractum ipecacuanhæ fluidum, oz. 4.
Spiritus ætheris compositus, oz. 4.
Acidum carbolicum, crystals, oz. 4.
Acidum aceticum, oz. 4.
Linimentum cantharides, oz. 4.
Acidum sulphuricum, oz. 4.
Acidum nitricum, oz. 4.
Liquor potassæ, oz. 4.
Cupping glasses, No. 6.
Clinical thermometer in case, No. 1.
Urinometer in case, No. 1.
Spaces for powders.

Tray No. 4, of the same length and breadth as the preceding, and 8 inches deep, is not subdivided into compartments, and is designed for an assortment of miscellaneous articles. Its arrangement is represented in Fig. 5.

The tray contains—

Unguentum hydrargyri, cans 1.
Ceratum simplex, cans 1.
Extractum nucis vomicæ, oz. 1.
Castile soap, lb. 1.
Brown soap, lbs. 2.
Candles, sperm, lbs. 4.
Candlesticks, No. 2.
Nutmegs, oz. 2.
Sinapisms prepared, package 1.
Vials, prescription, assorted, doz. 1.
Trusses, single, No. 2.
Hard rubber syringe, 12 oz., No. 1.
Sponge, fine pieces, doz. ½.
Portfolio, No. 1.
Towels, doz. 1.
Muslin, yards 6.
Red flannel, yards 2.

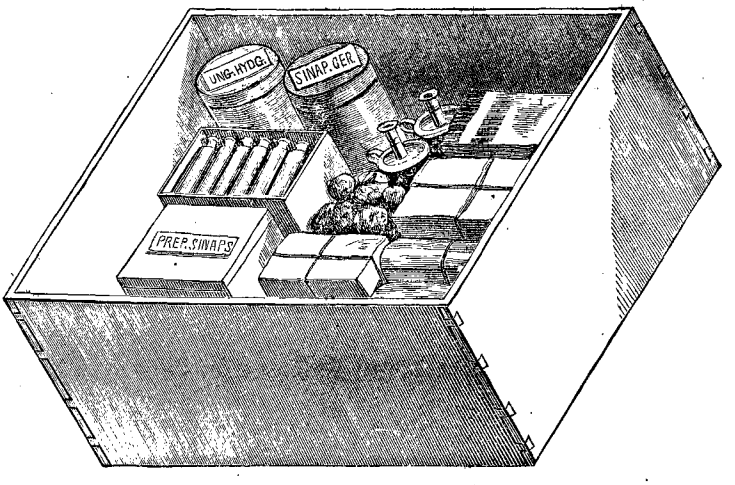


FIG 5.—Tray No. 4 of medicine chest.

Tray No. 5, of the same superficial dimensions as the others and 8 inches deep, is devoted to hospital stores.

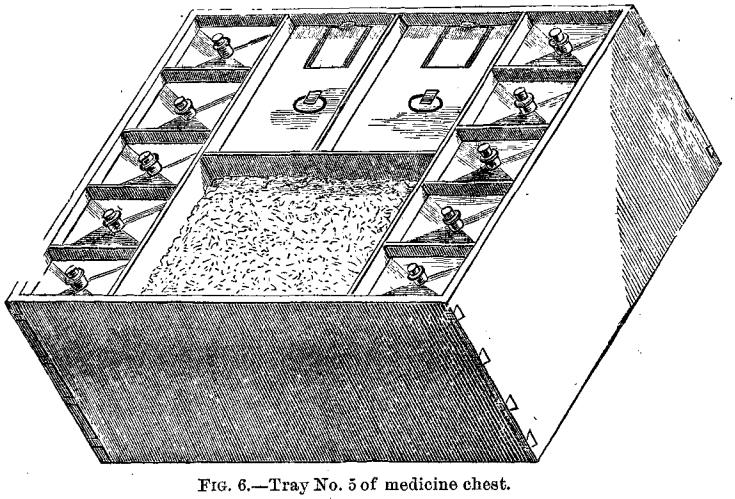


FIG. 6.—Tray No. 5 of medicine chest.

The tray contains—

Spiritus vini gallici, oz. 24.
Spiritus frumenti, oz. 24.
Spiritus rectificatus, oz. 24.
Oleum olivæ, oz. 12.
Syrupus scillæ, oz. 12.
One tin can for magnesiæ sulphas.
One tin can for pulvis lini.
One tin can for white sugar.
Two spaces left to be filled at discretion.

Mess chest.—The mess chest has been furnished with such utensils as are commonly on hand at every post, and is intended to supply the wants of a temporary field hospital for twelve patients. It has a set of three black walnut trays, each 12 inches wide and 16 inches long, fitting one

above another. The remainder of the chest is left vacant for packing the larger utensils.

Tray No. 1 is 4 inches in depth and is subdivided as shown in the diagram (Fig. 7).

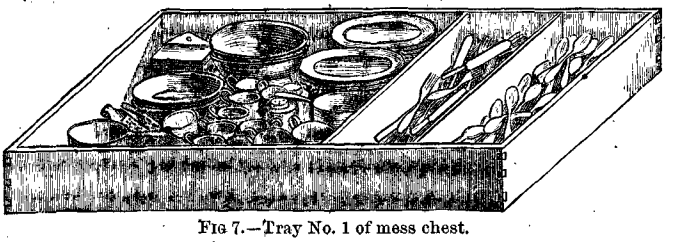


FIG 7.—Tray No. 1 of mess chest.

This tray contains—

Knives, table, No. 12.
Knives, carving, No. 1.
Forks, table, No. 12.
Forks, carving, No. 1.
Spoons, table, No. 12.
Spoons, tea, No. 12.
Nutmeg grater, No. 1.
Plates, tin, doz. 1.
Pepper box, No. 1.
Salt box, No. 1.
Tin case for matches, No. 1.

Tray No. 2 of the mess chest is 5 inches in depth, and, designed for cans and packages of various sizes, is not divided into compartments.

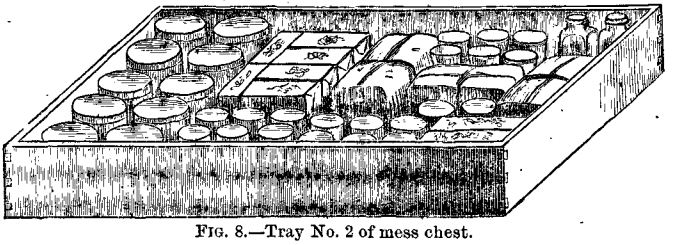


FIG. 8.—Tray No. 2 of mess chest.

This tray is intended to be packed with extract of beef in cans or jars, condensed milk in cans, farina in papers, corn-starch in papers, and any other article of nourishment or comfort for the sick which may be regarded as necessary by the medical officer.

Tray No. 3, 6 inches deep, is divided into compartments and furnished with tin cans, as indicated in the subjoined cut (Fig. 9).

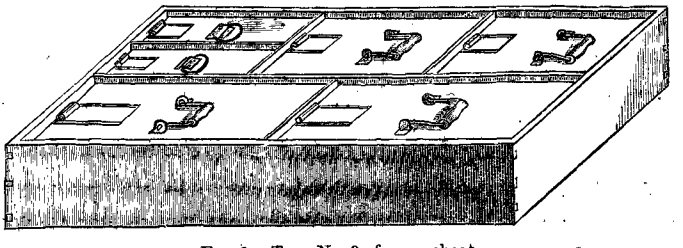


FIG. 9.—Tray No. 3 of mess chest.

This tray contains cans for—

Butter.
Coffee, ground or green.
Pepper.
Salt.
Sugar.
Tea; or for any other articles desired.

The large space in the chest unoccupied by the trays is to be packed with the following articles:

Basin, tin, washhand, No. 2.
Cleaver, No. 1.
Cups, Britannia, No. 12.
Cups, tin (1 qt., 1 pt.), No. 2.
Dippers, assorted, No. 2.
Dishes, tin, No. 6.
Grater, large, No. 1.
Gridiron, No. 1.
Kettles, camp, covered, No. 1.
Kettles, tea, iron, No. 1.
Knives, butchers', No. 1.
Ladles, No. 1.
Lantern, No. 1.
Pans, frying, No. 1.
Pans, sauce, No. 1.
Pots, coffee, tin, No. 1.
Pots, tea, tin, No. 1.
Saws, butchers', No. 1.
Steelyards, No. 1.
Trays, tin, No. 1.

To secure the articles contained in the mess chest against injury by motion, it will be advisable to pack the spaces firmly with oakum, or some yielding and clean material. Oakum is mentioned from the fact that it is nearly always found at posts, is cleanly, and, in cases of emergency, may be taken into use as a surgical dressing, or to pad splints.

In case it is thought advisable to enlarge the list above given, by the addition of the "Norwegian Kitchen," or cooking apparatus, the contents of the larger space may, by a little practice, be so economically disposed as to give sufficient room for it.

It is believed that everything which can contribute to the well being of the sick men of a small command in the field has been provided in these chests, so far as space would allow.

Surgical chest.—By direction of the Surgeon-General, Assistant Surgeon G. A. Otis, U. S. A., was charged with the outfit of the surgical chest. The objects held in view were to provide an adequate supply of restoratives, anæsthetics, instruments, and appliances for every primary dressing or operation needful and practicable in the field, and to eschew everything superfluous.

This chest contains, in the first place, a set of such carpenter's tools as are requisite for rough and ready work about a field hospital. These are packed in the uppermost of two black walnut trays, of the superficial dimensions of the interior of the chest, as follows:

LIST OF CARPENTER'S TOOLS IN TRAY NO. 1.

Hand saws (1 rip, 1 cross), No. 2.
Key-hole saw; No. 1.
Hammer, claw, No. 1.
Hatchet, with hammer head, No. 1.
Draw knife, No. 1.
Chisel, ¾ inch, No. 1.
Gouge, ½ inch, No. 1.
Brace, and complete set of bits, No. 1.
Screw-driver, 8 inch, No. 1.
Wire pliers, 1 round, 1 flat, medium size, No. 2.
Forceps, assorted, as used by gas-fitters, No. 3.
Screw or monkey wrench, medium size, No. 1.
Tool chest (so called) or hollow handle fitted with brad-awls, &c., No. 1.
Square, carpenter's, medium size, No. 1.
Compass, carpenter's, medium size, No. 1.
Tacks, papers, assorted sizes, No. 3.
Brads, medium size, papers, 1.
Nails, shingle, lbs. 1, 8-penny, lbs. 2, 10-penny, lbs. 1.
Screws, assorted, lbs. 2.
Plane, smoothing, short, No. 1.
File, half-round, medium size, No. 1.
File, rat-tail, medium size, No. 1.
Hone, No. 1.

The second or center tray is furnished with the following articles:

Candles, best sperm, lbs. 2.
Flint and tinder, and steel, in tin box, No. 1.
Lamp, alcohol, Mauck's patent, in tin heating vessel, No. 1.
Note-paper, commercial, quires 3.
Penholders, No. 2.
Memorandum paper, block, 1.
Pens, steel, No. 12.
Inkstand, traveler's, No. 1.
Roller, bandages, muslin, 1 in. x 1 yd., 12; 2 in. x 3 yds., 24; 2, 2½ ins. x 3 yds., 24; 3 in. x 4 yds., 12; 3½ in. x 5 yds., 12; 4 in. x 6 yds., 6; 4 in. x 8 yds., 6. } doz. 8.
Triangular compresses, large 50, small 50.
Wire gauge, for splints, yds. 1.
Adhesive plaster, in tin cases, yds. 10.
Ichthyocolla plaster, in tin cases, yds. 4.
Oil silk, yds. 2½.
Lint, patent, best flax, in rolls, lbs. 4.
Ligature, thread, best linen, 16 in. long, waxed, and put up in papers, oz. ½.
Silk, best saddlers' or ligature, oz. 8.
Wire, silver suture, on spool, yds. 12.
Whisky, in flask, pint 1.
1 oz. bottle strong liquor ammoniæ.
1 box of 100 1 gr. opium pills.
1 leather covered 16 oz. flask chloroform, with a shoulder sling.
Wax, yellow, in paper, oz. 8.
Sponges, large, bleached, soft, bell, No. 2.
Surgeon's sponge, best velvet, medium assorted sizes, oz. 8.
Splints, felt (Ahl's), set 1.
Splints, wire, anterior (N. R. Smith's), No. 3.
Suspensory bandages, No. 6.
Œsophageal tube, No. 1.
Brushes, for gypsum dressing, No. 2.
Matches, wax, caus 6.
Matches, ordinary, package 1.

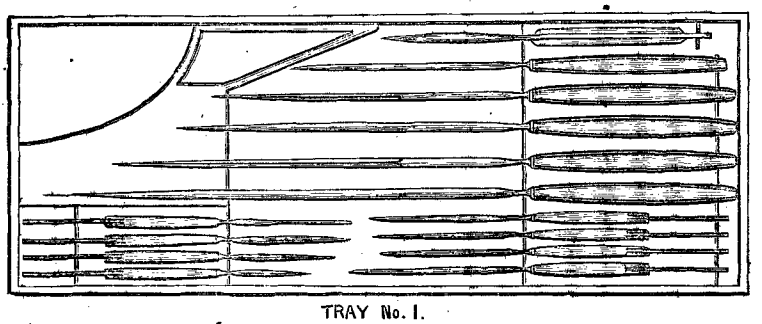
The third compartment or bottom of the chest is supplied as follows:

Candlesticks, No. 2.
Plaster of Paris, in tin cans, lbs. 10.
Chloroform, in tin can with screw stopper, lbs. 10.
Simple cerate, in can, lb. 1.
Powdered mustard, in can, lb. 1.
Twine (stout), 8 oz., finer, 8 oz.
Jack-knife, stout, with cork-screw, No. 1.
Spirits of camphor, oz. 16.
Elastic catheters, English, assorted, No. 6.
Alcohol, oz. 32.
Binder's board, for splints (2½ ins. x 12 ins. 6 pieces, 4 ins. x 17 ins., 6 pieces,) doz. 1.
Worsted binding (1 in. x 6 yds.), pieces 1.
Tape, stout linen, yds. 50.
Green silk, for eye shades, yards ½.
Camel's hair brushes, in phial, No. 12.
Wax tapers, boxes 2.
Needles, sewing, assorted, 25.
Cotton thread, spool, 3.
Shears, for gypsum bandage, No. 1.
Brass dressing pan (Army pattern), No. 1.
Drainage tubes, No. 6.
Napkins, for ophthalmia, doz. 1.
Roller bandages, flannel (4 ins. x 6 yds.), doz. 1.
Towels, doz. ½.
Oakum (q. s. to pack closely).
Cotton, antiseptic, rolls 2.
Cotton batting (q. s. to fill vacant spaces).
Steward's pocket case.
Compact field case.

As the two cases of surgical instruments allowed medical officers as personal sets for capital and minor operations are, necessarily, large and inconvenient for field transportation, Dr. Otis was instructed to select a set that should constitute a *compact field case*, mentioned in the preceding list as a part of the contents of the bottom compartment of the surgical chest. It has been his endeavor to place in the case such instruments as are necessary for primary operations for traumatic cause, not reducing their size below the best models in order to pack them in a narrow compass, but securing economy of space by careful

packing, and, in some cases, by making parts of instruments interchangeable.

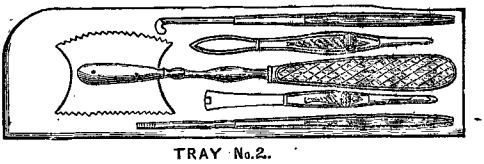
In a few instances, slight modifications, suggested by the experience of the war, have been introduced in well-known patterns of the arma-



TRAY No. 1.

FIG. 10.—Tray of the compact field case fitting over the compartment A, contains 1 strong cartilage knife, 1 small amputating knife, 1 medium catling, 1 medium amputating knife, 1 large catling, 1 major amputating knife, 1 straight sharp pointed bistoury, 1 curved sharp pointed bistoury, 1 probe pointed curved bistoury, 1 long straight probe pointed bistoury, 1 tenaculum, 1 large scalpel, 1 small and 1 very small knife for dissections and ligations.

mentarium. With the skillful collaboration of Mr. Stohlmann, of Tiemann & Co., it is believed that the effort to secure compactness, at least, has been remarkably successful. The drawings (Figs. 10, 11, 12) explain the arrangement of the case.



TRAY No. 2.

FIG. 11.—Tray of the compact field case fitting into compartment B, contains 1 Hey's saw, 1 torsion forceps, 1 needle forceps, 1 artery needle holder with 4 points and 1 key.

Two trays containing knives for amputations, excisions, and dissections, with artery needles and forceps and a Hey's saw, fit into the two compartments of the case represented in Fig. 12. The upper compartment, B, contains saws, probes, bullet-extractors, &c. The lower compartment, A, the tourniquet and large resecting instruments.

To save the surgeon's pocket case of instruments, it was thought advisable to add a steward's pocket case. This is of sheep's skin, in two folds, and holds a stout pair of scissors, a dissecting forceps, two probes, a spatula, a scalpel and bistoury folding in a shell-handle, a thumb-lancet, and, in a pocket, surgeon's needles, silk, &c.

The triangular compresses mentioned among the contents of the center tray, are made by dividing diagonally a yard square of unsized muslin. One, in the package, is printed with Esmarch's illustrations of Mayor's system of scarf-bandaging. With these compresses are put up fifty small compresses for primary application to fresh wounds, &c.,

consisting of a bit of lint and charpie, and a folded scrap of muslin; the whole enveloped in waxed paper.

The several chests were packed under the supervision of Lieut. Col. C. Sutherland, assistant medical purveyor, U. S. A. When loaded, the surgical chest weighed 203 pounds; the medical chest, 226 pounds; the mess chest, 173 pounds.

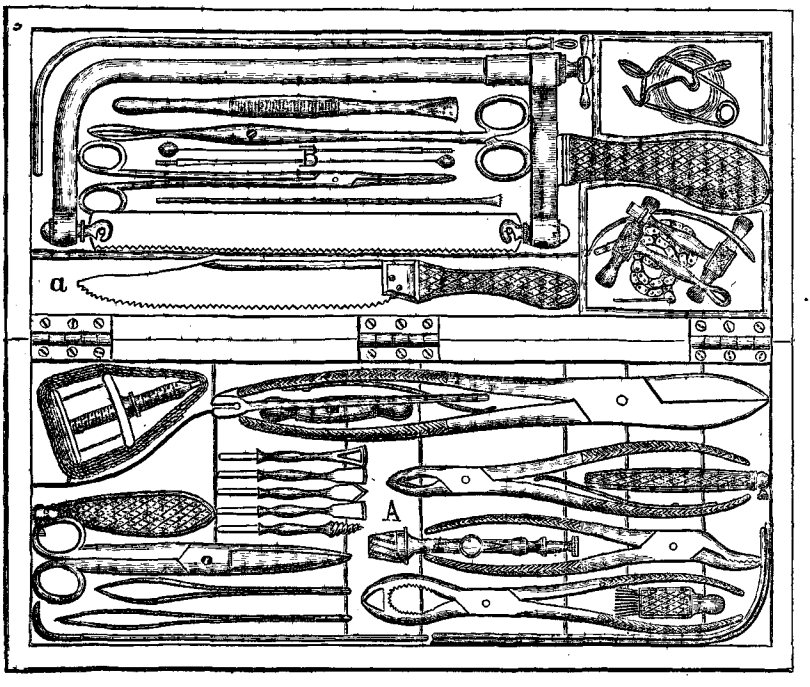


FIG. 12.—COMPACT FIELD CASE. *Compartment* A contains: 1 tourniqu t, 1 large Liston's bone cutter, 1 gnawing forceps, 1 sequestrum forceps, 1 Lion forceps, 1 conical trephine, 1 trephine-brush, 2 German-silver retractors, 1 osteotome, handle with four points, 1 tire-fond, 1 Ollier's curved osteotome and chain saw conductor, 1 scissors, 1 dissecting forceps, 1 artery forceps, 1 silver grooved director. *Compartment* B contains: 1 major saw with 2 extra narrower blades, 1 movable back saw, 1 English No. 6 gum elastic catheter, 1 elevator, 1 bullet forceps (model Gemrig), 1 bullet forceps (model Tiemann), 1 long articulated probe or *sonde de poitrine*, with 2 Nelaton or porcelain tips, and 1 burr-headed ball-searcher. In lower end tray, 1 chain saw (model Charriere) with conducting needle; in upper end tray, 10 large serres-fines, 2 coils of annealed iron wire. In tray D, under movable-back saw, silk, linen, and catgut ligatures, wax, silver suture wire, surgeon's curved needles, acupressure pins, 2 silver probes.

Three folded double colored blankets, of the hospital pattern, are to be strapped on the forward chest, and a rubber blanket to be spread and secured over the entire load. It is intended that the driver may sit on the front box, and experiment shows that in this position he has good control of the reins, and as firm a seat as the driver of a caisson. Iron loops or holdfasts have been attached to the forward braces of either panel for greater security.

The cart itself, without a load, weighs 420 pounds. Adding the weight of the three packed chests, or 602 pounds, allowing 50 pounds for the blankets and 148 pounds for the driver, the total weight to be drawn is 1,220 pounds. As it is estimated by the best authorities (Mc-

Adam and others) that a stout cart-horse fifteen and a half hands high should be equal to the traction of 3,200 pounds over ordinary roads at 3 miles an hour, the weight of the entire load is within limits even for long and rapid marches.

Several officers have advised that a detached seat supported by iron stays should be constructed for the driver; but to this it has been objected that such a seat would add to the complexity and expense of the vehicle, and make it more liable to be used for other purposes than that for which it is designed, and, principally, that such an arrangement would necessitate lowering the forward box and thus destroying the uniformity in the dimensions of the chests, which is an important feature in the plan.

This pattern of medical transport cart has not yet been tested in actual service; but the preliminary practical trials that have been made with it indicate that it will prove a convenient and important addition to the Army field equipment.

No. 5. Ambulance (full size) of the Wheeling pattern, made under the direction of Lieut. Col. J. A. Ekin, quartermaster, U. S. A.

No. 6. Ambulance (full size) of the pattern devised by Col. D. H. Rucker, quartermaster, U. S. A.

Nos. 6, 7, and 8. Three experimental ambulances, made at Watervliet Arsenal, under the direction of Col. P. V. Hagner, U. S. A., in accordance with designs furnished by a Board of Army Officers, of which Col. Rufus Ingalls, quartermaster, U. S. A., was president, and Assistant Surgeon G. A. Otis, U. S. A., recorder.

REPORT ON THE MATERIAL AT THE EXHIBITION

PERTAINING TO

ARMY MEDICAL SCIENCE AND ADMINISTRATION,

BY

ASST. SURGEON J. J. WOODWARD, MEDICAL DEPARTMENT, U. S. A., IN CHARGE OF MEDICAL SECTION, WAR DEPARTMENT PARTICIPATION.

Bvt. Lt. Col. S. C. LYFORD,

Representative of the War Department, and Chairman of the Board on behalf of the United States Executive Departments:

SIR: In accordance with the instructions of your letter of May 26, 1876, I have examined such portions of the general exhibition as relates to the proper work of the medical staff of armies, and now offer the following brief report in relation thereto.

But, in the first place, I must say that I cannot sufficiently regret that foreign nations were not particularly invited to send exhibits representing the methods employed by the medical staffs of their several armies for preserving the health of troops, and for the treatment and cure of the sick and wounded.

Surgeon-General Barnes suggested, in the spring of 1874, that such invitations should be sent. In his letter of May 5 of that year, to the honorable Secretary of War, he uses the following language:

> It is, in my opinion, very desirable that the army medical departments of other Governments should be represented at the International Exhibition in connection with our own Medical Department. This could not but lead to a beneficial interchange of ideas, and to a comparison of the various devices employed in the care of the sick and wounded, which could not fail to advance the best interests of medical science. I recommend, therefore, that appropriate invitations may be extended to these medical departments through the proper official channels.

If it had been deemed expedient and practicable to carry out this plan, it may well be believed that the advantages anticipated by the Surgeon General would have been fully realized. Not merely would benefit have accrued from the facilities afforded for the study and comparison of the various devices employed by different armies, but such exhibits as it was hoped would be obtained would undoubtedly have been accompanied by medical officers of the armies of the several nations, who would thus have been afforded an opportunity for comparing opinions on all that relates to the health of troops, which could not but have proved mutually instructive. As it was, although several Governments and a number of private individuals made interesting exhibits in

Philadelphia of matters pertaining to the Medical Service of Armies, none of the foreign Governments attempted a systematic display of its own characteristic methods and appliances in this branch of army administration.

The articles exhibited consisted for the most part (*a*) of devices for use in connection with the transportation of the sick and wounded, or of medical and surgical supplies for their use, and (*b*) of surgical instruments and appliances. As both these groups of objects illustrate subjects which have been particularly studied by my colleague, Bvt. Lieut. Col. G. A. Otis, assistant surgeon U. S. A., I have requested him to examine them, and express an opinion as to the character and merits of those which appeared to him to be of special interest or importance. He has been so obliging as to comply with my request, and has prepared a statement, which I forward herewith as a supplement to my report.

The following is a brief sketch of the extent and character of the exhibits of this kind. Four Governments, Sweden, Russia, Spain, and Japan, notwithstanding the absence of special invitations, voluntarily manifested their interest in the welfare of wounded soldiers by exhibiting contrivances for their treatment and for their removal from the field of battle.

Everything else relating to the subject under consideration to be seen in the exhibits of other foreign countries was furnished by the enterprise or philanthropy of private individuals or societies. The most extensive, and in many respects the most interesting, collection of the kind in the whole exhibition, that in the display of the German Empire, was not sent by the Government, but from private sources, although the interest taken in the subject by this enlightened Government was indicated by the fact that the Empress herself directed the sending of one or two articles, which will be referred to hereafter. In fact, I must express the opinion that the limited extent to which the Governments sent exhibits of this character was in nowise due to their apathy or indifference with regard to the health of armies, or the relief of the suffering which follows battles, but was simply owing to the fact that no special effort was made to invite their attention to the subject.

The Swedish Government (sanitary department of the Royal War Office) exhibited, in the main building, two cases of surgical instruments, such as are used by the medical officers of their army, and made by Alb. Stélle, of Stockholm; also, a compact two-horse medicine wagon, intended to carry supplies with troops in the field.

The Russian Government exhibited, in the main building, several cases of surgical instruments for use by surgeons, assistant surgeons, and veterinary surgeons, and in machinery hall a very interesting (full size) model ambulance, which, since the close of the exhibition, has generously been presented to the Army Medical Museum.

The Spanish Government had a separate building, in which an in-

teresting collection of models and other objects relating to the military service was displayed. Among these there were two stretchers for carrying the wounded, several small models of mule-litters, cacolets, panniers. &c., a full-sized pack-saddle, with a pair of panniers containing medicines and surgical appliances for field service, and a collection of bandages, splints, and dressings for the treatment of wounds.

The Japanese Government (Imperial War Department) exhibited a small collection of litters and stretchers. Among them there was a wheeled litter for carrying a single wounded man, one for carrying two wounded men, and several hand-litters with bamboo poles.

As already stated, the comparatively extensive, and certainly the most interesting, collection in the German department was not a Government display. The directors of the Lower Silesian and Markish Railway exhibited a small model of a railway car, such as is used on the German roads, fitted up with stretchers to carry ten sick or wounded soldiers in the reclining position; full-sized models of the stretchers, to show their construction and the method of suspending them; and a model of a German railway car fitted up as a kitchen, with cooking-range and utensils intended to do the cooking for a train of sick and wounded. Also a portfolio of drawings representing a complete sanitary train. N. Plambeck, of Hamburg, also exhibited a small model of a railway car fitted up with stretchers for the transportation of eight wounded men, and full-sized models of stretchers and contrivances for suspending them.

Quite a collection of stretchers and litters, two of them mounted on wheels, were exhibited by Edward Lipowsky, of Heidelberg, who also exhibited models of a plan for suspending litters in railway cars and other vehicles, and a variety of operating tables and chairs, bathing apparatus, sick-beds, and other appliances for the sick-room.

Prof. Friedrich Esmarch, of Kiel, exhibited the apparatus employed in his "bloodless operations"; his apparatus with elastic extension for the transport of fractured thigh; his triangular bandage for the extemporaneous dressing of wounds ("Der erste Verband"); his apparatus for carrying and administering chloroform in the field, and a small dressing-case for field service.

Dr. Julius Port, of Munich, exhibited a collection of splints extemporized from telegraph wires, designed for the treatment of gunshot fractures of both upper and lower extremities. This collection has been presented to the Army Medical Museum at the request of the exhibitor.

The surgical clinic of the University of Koenigsberg (Professor Schoenborn, director) exhibited a collection of the "gypsum and hemp combination splints" invented by Dr. F. L. Beely, with photographs showing their adaptation to fractures of both upper and lower extremities.

G. Horn, of Kiel, exhibited an assortment of handsomely carved wooden splints for both upper and lower extremities.

Dr. Bernard Beck, of Carlsruhe, exhibited a collection of splints ex-

temporized by sewing and tying bundles of straw together. This collection has been presented to the Army Medical Museum at the request of the exhibitor.

Paul Hartmann, of Heidenheim, exhibited a collection of bandages, lint, and other materials for surgical dressings.

A model of a "corridor barrack hospital" was exhibited by Dr. Zuelzer, of Berlin, and one of a "pavilion barrack hospital" by the Association of the circuit and town of Altoona, for nursing sick and wounded soldiers.

The Central Committee of the Bavarian Association for Nursing and Aiding Sick and Wounded Soldiers, exhibited a life-sized model of a member of the volunteer sanitary corps, uniformed and equipped, and the directors of the Badish Aid Association a series of photographs representing scenes illustrative of the usefulness of the association in hospitals and in the field.

Finally, on a large table in the midst of this collection lay the published reports of the various German associations for the aid of sick and wounded soldiers, exhibited by their central committee, and a number of publications on sanitary subjects, exhibited by Carl Heymann, of Berlin.

On the same table were the two articles sent by direction of Her Majesty the Empress Augusta, to which I have already referred. The first was a volume entitled "The Red Cross at the Vienna Exposition of 1873,"* containing about thirty photographs representing the hospital cars, ambulances, and other devices for the cure of the wounded, exhibited at the Vienna Exposition. The second was a pocket-case, intended as a *vade mecum* for officers and men in time of war, which the attendant informed me was also prepared at the instance of the Empress, who caused the distribution of a considerable number during the Franco-German war. The case contained the triangular "first bandage" of Esmarch, with a little collection of plasters and dressings, a knife, a pair of scissors, a few small vials containing medicines for use in emergencies, and a copy of a pamphlet entitled "Wie hilft man sich," published by Die internationale Verbandstoff-Fabrik in Schaffhausen, in which brief directions are given for the use of each of the articles contained.

In the Netherland section of the main building there was a small collection consisting of the following objects:

A series of plaster of Paris bandages, made by Dr. A. Mathijsen to illustrate his method of treating fractures, and a series to illustrate the modification of this method, by Dr. J. P. H. Van de Low. Both collections were accompanied by descriptive brochures.

The Netherland Society for Aid to the Sick and Wounded in War exhibited a series of its publications.

*Das rothe Kreuz in der Wiener Welt-Austellung, 1873. Dargestellt auf anregung ihrer Majestät der Kaiserin Augusta, durch das deutsche Central-Comité zur Pflege im Felde verwundeter und erkrankter Krieger.

Dr. M. W. C. Gori exhibited two books, of which he is the author, entitled "La chirurgie militaire et les sociétés de secours à l'Exposition universelle de Vienne, 1873," and "Des hôpitaux tentes et baraques."

At the request of Dr. Gori, and the other exhibitors, this Netherlands collection has been presented to the Army Medical Museum.

The foregoing somewhat slender list embraces all that I found in the exhibition which related directly to the proper work of the medical staff of armies.

So far as it consisted merely of printed books, the knowledge thence to be derived would have been just as attainable if the exhibition had not existed. An international exhibition should supplement the knowledge furnished by books by a display of the things, or working models of the things which the books discuss. Seen from this point of view, it must be admitted that aside from the exhibition of the Medical Department of own Army, the sanitary interests of armies were represented in the Exhibition of 1876 in a very incomplete and fragmentary manner.

In the exhibition of our own Medical Department, as will be seen by the explanatory catalogue, four classes or groups of objects were displayed. 1. Hospitals; 2. Modes of transportation; 3. Medical and surgical supplies; 4. Methods for the systematic study of the diseases and injuries of soldiers, with a view to their better treatment.

(1.) *Hospitals* were represented by a barrack post hospital of the pattern at present authorized in our military service; by a tent pavilion, consisting of three hospital-tents placed end to end, and by a series of models representing the forms of construction and arrangement which were found most desirable for large barrack hospitals during the civil war of 1865. It is well known that the published accounts of our hospital system attracted great attention in Europe, and that in the Franco-German war of 1870–'71, both combatants made use to a considerable extent of what has become known as the American system of barrack hospitals. Something of the details of what was done, of the difficulties experienced, the modifications introduced, and the degree to which these modifications proved beneficial, may be learned from several French and German publications in which the subject has been discussed.* It would therefore have been particularly interesting, as well as instructive, if we could have seen in Philadelphia models of some of the field hospitals of that war. But the only objects bearing on the construction of military hospitals were the two models mentioned above in connection with the German collection. The design of the "pavilion barrack hospital," exhibited by the Altoona Association was not without merit.

* As for example: DEMOGET. Étude sur la construction des ambulances temporaires. Paris, 1871.—LEVY. Note sur les hôpitaux-baraques du Luxembourg et du Jardin des plantes. Annales d'hygiène, tome 35 (1871, p. 116).—GRELLOIS. Histoire médicale du blocus de Metz. Paris, 1872.—STEINBERG. Die Kriegslazarethe und Baracken von Berlin. Berlin, 1872.—ESMARCH. Verbandplatz und Feld-Lazareth. 2d ed. Berlin, 1872; also by the same: Ueber Vorbereitung von Reserve-Lazarethen, in Kriegerheil, Beiheft 3, Berlin, 1870, &c.

It consisted of a central administration building from which four one-storied pavilions radiated at right angles to each other. Each pavilion contained near the administration building a ward for eight beds, and at its distal extremity two smaller wards each for two beds; the water-closet, bath-room, &c., were between these smaller wards and the larger one. The model was rather rudely made of tin, and was not accompanied by any description. The attendant informed me that it represented simply a plan proposed, not one which had actually been tried. The same remark applies to the model of the corridor barrack hospital by Dr. Zuelzer. This represented a hospital several stories high, cut up into a number of rooms, and the model was so incomplete that, in the absence of any description, it was impossible to understand the system of ventilation proposed, or even the details of administrative arrangement.

No hospital tents of any kind were exhibited. I noticed, however, in the British department of the main building, in the exhibit of George Turner & Co. (94 Grace Church street, London, E. C.), travelers' outfits, a photograph of the "Emmanual small-pox convalescent hospital," constructed by this firm at Ascot in 1871. It appeared, from the photograph, to be a modification of "star marquee," which this firm manufactures for balls and lawn parties. This is a central circular tent, with six oblong wings radiating from it like the spokes of a wheel, the whole provided with ventilation by the ridge; it looked very handsome in the photograph, but I should presume would be much more difficult to pitch than our own hospital tents, and did not impress me as offering any advantages for military service.

(2.) Our own *modes of transportation* were represented by models of the plans actually employed during the late civil war to adapt the rolling-stock of American railroads to the transportation of the sick and wounded, and especially on the longer routes to organize complete hospital trains, with kitchen and dispensary cars, constituting in fact complete moving hospitals on wheels; by models of the hospital steamboats and steamships employed during the same war—true floating hospitals for river or ocean service; by models of ambulances, stretchers, and litters of various patterns, and full-sized representatives of the same, and by models and full-sized medicine wagons, medicine carts, panniers knapsacks, &c., for the transportation of supplies in the field. No foreign hospital vessels were exhibited, by model or even by drawings, which is the more to be regretted because it is well known that considerable attention has been given to the subject abroad, particularly by the English, who have fitted up several hospital ships which have done good service in foreign wars.

Foreign railroad transportation was represented by the models in the German collection, which will be discussed in the appended report of Dr. Otis.

Other transportation was represented by the Russian ambulance,

the Swedish medicine wagon, the Spanish mule litters and panniers, and a variety of litters and stretchers, which will also be discussed in the report of Dr. Otis.

(3.) *Medical and surgical supplies.*—In our own collection all the articles actually authorized for issue by Army regulations, in the way of hospital furniture and bedding, kitchen and mess furniture, medicines, hospital stores, surgical instruments and appliances, together with such meteorological instruments, tools, and miscellaneous articles as are issued by the Medical Department for field or hospital service, were represented by samples of the articles themselves borrowed for the purpose from the stores of the medical purveyor. If it had been possible to have had at Philadelphia similar collections from the leading armies of the world, the comparison would undoubtedly have been suggestive to the medical officers of all countries, and would probably have led to modifications by all in the direction of increased comfort for the sick and wounded. But no foreign collection of the sort was present. The articles from abroad belonging to this group which actually were exhibited were some cases of surgical instruments and a few special devices for the treatment of gunshot wounds, or to facilitate surgical operations, an appreciation of which will also be found in the report of Dr. Otis.

(4.) *Methods for the systematic study of the diseases and injuries of soldiers, with a view to their better treatment.*—In our own collection these methods were represented by the various forms of blanks and books issued to medical officers for recording their observations bearing directly or indirectly on these subjects, and for representing them to the Surgeon-General's Bureau; by the catalogues of the Army Medical Museum, and by specimens and photographs intended to indicate the scope and character of its collections; by catalogues, &c., to represent the scope and character of the library of the Surgeon-General's Office (National Medical Library), and by a set of the publications of the Surgeon-General's Office and other official publications of the officers of the medical staff, which may be regarded as the outcome of the activity of the department in this direction.

Nothing of this kind was exhibited by any foreign nation, and this is the more to be regretted, because it is well-known to us that systematic efforts in the same direction are made by almost all the highly civilized nations. Thus Great Britain possesses the splendid establishment at Netley, where there is a growing museum and a fully organized and equipped army medical school, with lecture-rooms and laboratories designed for the purpose of training young medical men for the special duties of the army service; a similar establishment (Val de Grâce) exists at Paris, in connection with the medical department of the French army; at Berlin (the Pepinière) for the German army; at St. Petersburg and at several other capitals. All these nations exact systematic reports from their medical officers, and possess at the central bureau of their medical departments more or less complete machin-

ery for examining and discussing these reports, for the double object of supplying the proper authorities with such information with regard to the health of the army as is needed for administrative purposes, and of publishing from time to time such facts and deductions as may seem likely to be useful in connection with the progress of scientific medicine and surgery.

Now, it must be greatly regretted, that these various organizations could not have been represented at Philadelphia in such a way as to have facilitated a better knowledge by each of the organizations and resources of the others; a kind of knowledge which is the more desirable because it is not attainable from the books with satisfactory completeness and detail. From what is already known, however, I am satisfied that the mutual comparison of these organizations would have been instructive and beneficial to all, and especially I must express the belief that it would have disabused our people of the idea that our own Army Medical Museum and Library have been liberally or even adequately provided for, and would have satisfied them that by a judicious increase of expenditure, their usefulness could be greatly extended.

In short, my study of the Philadelphia Exposition has strengthened the opinion I had previously formed of the advantages to be derived from a properly organized exhibition of the apparatus and methods of the medical departments of the armies of civilized nations, especially if the display of each nation were accompanied by one or more trained officers of its medical staff. An international congress of such officers could not fail to bring about material improvements.

Interesting collections of objects relating to the subjects under consideration were exhibited at the Paris Exhibition of 1867, and the Vienna Exposition of 1873. At both, international conferences assembled for the purpose of examining and discussing the collections and the subjects suggested by them. These assemblies were attended not only by distinguished representatives of the several aid societies, but also by some of the most accomplished medical officers attached to the European armies. Although at neither meeting was the scope of the discussions as broad as is contemplated in the remarks just made, the beneficial results of the discussions at Paris and Vienna may be confidently referred to as an argument in favor of still further efforts in the same direction.

Another subject suggested to my consideration during the Philadelphia Exhibition was that of the voluntary aid societies, which have done such good service in supplementing the exertions of the army medical staffs in recent European wars. Although some of these societies are quite old, their recent activity is undoubtedly due, in part at least, to the reports of the usefulness of the sanitary and Christian commissions in our own civil war.

It is true that the humane Geneva Convention of 1864, without which

the successful operations of these societies would have been greatly embarrassed, was due to other causes, among them, no doubt, in part at least, to the awakening of the conscience of Europe by the terrible picture drawn by Durant* of the horrors that followed the battle of Solférino; but many of those who have taken an active part in the recent development of the European aid societies were undoubtedly stimulated by the American example, as is freely acknowledged in their writings. Experience has shown that the extremely economical organization to which even the most intelligent Governments have always limited the medical staff of armies in time of peace is seldom adequate to meet the demands made upon it during wars of any magnitude, especially at their commencement, and the voluntary aid of the humane will always be desirable under such circumstances. What form should be given to these voluntary efforts? To what extent is it necessary that they should be subordinated to the authority of the medical staff, especially in the field? What measures are advisable to secure the most advantageous expenditure of the funds voluntarily contributed, to avoid the wasteful purchase of articles already in store, to the neglect of those actually needed, or of mere luxuries, when necessaries are solely deficient? How can the voluntary organizations best secure the dicipline and responsibility of their own subordinates, which is absolutely essential to the success of their humane intentions? These are a few of the many delicate questions which surround the subject of voluntary aid societies, and with regard to which the recent European experience could not fail to be instructive. The literature bearing on the question is quite sufficient to serve as a basis for the intelligent discussion of these questions. I should feel, however, that I was going beyond the proper limits of the present report if I were to attempt to discuss them here, for the Philadelphia Exhibition did not bring together the necessary data for the purpose, and I should be compelled to go quite outside of it for a large portion of the essential facts.

The European societies were represented at Philadelphia only by the publications of the German and Netherlands societies, and by the Bavarian model already mentioned. The latter interested me greatly. The figure is in uniform, black pasteboard helmet, gray coat with black facings, and black pantaloons tucked in the boots. On the left arm is a white band with the Geneva red-cross in its center. He carries a black cloth overcoat, rolled and thrown across his shoulders, and a thin india-rubber overcoat folded on his knapsack. His knapsack is devoted chiefly to his own clothing, but has also a pocket in which small quantities of bandages and lint are stored. He carries also one of Esmarch's small field companions for first dressings, a hatchet, a small bottle of

* DURANT: Souvenir de Solférino. Genève, 1862. See especially, in this connection, the work of Dr. C. LUEDER. Die Genfer Convention, Erlangen, 1876, a copy of which was exhibited in the German collection above mentioned. [There is also a copy in the library of the Surgeon-General's Office.]

spirits, and an oval tin box which appears to be intended for the double purpose of cooking and carrying water. Finally, there was a strong webbing-strap, with a loop at each end, carried over his shoulders, intended for use when serving as a stretcher-bearer. This figure is described in the official German catalogue as a "model of a fully dressed and completely equipped member of the voluntary sanitary corps." It suggests the idea of a trained and instructed "bearer of wounded," whose service, indeed, is voluntary, but who has submitted himself to military discipline for the sake of his benevolent object; who willingly does his work in co-operation with the organized medical staff, and in loyal subordination to it. To what extent does this idea, suggested by the German model, represent the actual workings of the volunteer aid associations in the field during the Franco-German war? We shall not be able to decide merely by an examination of the reports exhibited at Philadelphia. An examination of these reports, especially that of the Central Committee of the German societies,* will give a good idea of the liberality with which private citizens of all classes, during the Franco-German war, contributed money, supplies, and personal services to aid in alleviating the miseries of war; and will serve to satisfy the reader that great good was actually done by these humane organizations. But it will be necessary to seek elsewhere for an account of the serious difficulties, misunderstandings, and embarrassments which occurred in various quarters,† or for a thorough and practical discussion of the proper functions of aid societies, and of the relations which they should sustain to the medical staff of armies, in order that the most efficient relief attainable may be afforded to the sick and wounded whose succor is the common object of both.

After I had become convinced of the extremely limited extent to which the sanitary interests of armies were represented at Philadelphia, I took pains to examine such portions of the exhibition as related to the general interests of medicine and surgery, hoping to find matters of importance to incorporate in my report. I soon became satisfied, however, that any attempt at a detailed appreciation of the frag-

*Bericht des Central-Comités der deutschen Vereine zur pflege im Felde verwundleter und erkrankter Krieger über seine Thätigkeit und die Wirsamkeit der mit ihm verbundenen Vereine während des Krieges von 1870-71. Berlin, 1872. A copy of this report was received at the library of the Surgeon-General's Office in November, 1872, through the State Department, having been sent by the United States consul at Berlin.

†Some of these embarrassments are mentioned by LUEDER, *op. cit.* Consult also, in this connection, LONGMORE. On the German Convention of 1864, in relation to the aid afforded by volunteer societies to sick and wounded soldiers during the late Franco-German war, with a glance at the proper functions of national aid societies, particularly the British Aid Society in the future. London, 1872. Also, by the same, replies to questions from the British National Society, for aid to the sick and wounded in war, with some remarks on previous replies to the same. London, 1872. Also, Questions on the operations of the British National Society for aid to the sick and wounded in war, and replies thereto. London, 1872.

mentary collections which came under this head could hardly prove sufficiently useful to repay the great expenditure of time and labor which it would require.

If we except the displays of the Medical Department of our own Army and Navy, and the well-administered local hospital service for the care of those taken sick or accidently injured on the grounds, the medical profession, whether of our own or of foreign countries, was in no proper sense of the word represented in the Exhibition. On the other hand, the great majority of the exhibits of the manufacturers and dealers in surgical instruments and appliances, of drugs, chemicals, and pharmaceutical preparations represented American houses, whose products are too well known to the medical officers of our Army, and to the American medical profession generally, to make any detailed account of their character desirable in this place; while in the foreign exhibits the most important and extensive establishments known to us were, with a few exceptions, unrepresented. In the matter of prothetic apparatus, for example, which was represented by a considerable number of American manufacturers, the only foreign exhibit was a small case containing a few rather rudely-made pieces of apparatus (arm, leg, &c.), in the collection of the Argentine Republic. Among the foreign medical exhibits which particularly arrested my attention, I may mention the large and curious collection of Chinese drugs and medicines, and the large collection of medical herbs and plants in the exhibit of the Argentine Republic. It is to be regretted, however, that neither of these collections were so catalogued as to give satisfactory information with regard to most of the samples; for most of them the native common names alone were given, and in the case of the vegetable productions, as the part used for medicinal purposes alone was exhibited, it was, in most instances, out of the question to attempt to identify the plant from which they were derived. In this connection, I cannot avoid mentioning the better catalogued and very interesting collection of our own indigenous medicinal plants exhibited by the Wallace Brothers, of Statesville, N. C. I was also greatly interested in examining the collection of admirable dissections of the internal ear, by Dr. Adam Politzer, in the Austrian exhibit, which, I am happy to learn, will remain in this country, as it has been purchased for the museum of the College of Physicians of Philadelphia.

In Machinery Hall my attention was directed to the elaborate apparatus for mechanical gymnastics, exhibited by Dr. G. Zander, of Stockholm. Twelve machines were displayed, many of them worked by steam power, and some of them extremely complex. Dr. Zander, their inventor, directs an establishment in Stockholm, known as the "Mechanico-Therapeutic Institute," in which, according to the official Swedish Catalogue, no less than fifty machines of this sort are now in use. According to the same catalogue, a complete system of these machines, consisting of thirty machines for active movements, and eighteen for passive move-

ments, will be delivered on board in Stockholm for $15,000 in gold. These machines are devised to secure systematic exercise, whether active or passive, not merely for the purpose of favoring the harmonious development of the muscular system, but it is claimed that they exert a beneficial influence in a great variety of chronic diseases, for the treatment of which many of them are especially designed. While the ingenuity of some of them must be freely acknowledged, and while it cannot be doubted that systematic exercise, both active and passive, is capable of exerting a beneficial influence in many morbid conditions, I cannot but feel great doubt, in the present state of inquiry in this direction, as to how far such complex devices are necessary for all useful purposes; indeed, I am uncertain whether the probability that injury would result from the injudicious application of the powerful forces which some of them represent is not great enough to outweigh any advantages to be derived from their use. I also examined in Machinery Hall the ice machine invented by Raoul Pictet, and exhibited by Étienne Gillet (No. 13 Barclay street, New York), to which my attention was particularly drawn by an order received from the Surgeon-General, directing me to inquire how far it was adapted for use for the hospitals of those military posts at which it is difficult to obtain a supply of ice from the usual sources.

In this machine the necessary degree of cold is produced by the volatilization of sulphurous anhydride, which is subsequently recondensed by steam-power. It is claimed in favor of this method that sulphurous anhydride does not give a pressure greater than four atmospheres at a temperature of 95° Fahr., and liquefies at the ordinary pressure at 14° Fahr., that it is not combustible, that it has the exceptionally advantageous property of being an excellent lubricant, and that it is the least expensive of all volatile liquids. I saw at once that the sample machine exhibited at Philadelphia was larger than would be required for any of our post hospitals, learned from the agent that it was quite costly, and observed that it would require a steam-engine and a competent engineer to run it; but I could not form any opinion of its actual merits, because it was not in operation, and the person in charge could give no satisfactory information as to the details of its construction. I therefore wrote to Mr. Gillet to learn whether I could see the machine in operation by visiting his establishment in New York. In his reply he informed me that the inventor was now engaged in perfecting a modified machine, designed to be worked by hand instead of steam power, of small size, with a view to easy transportation, and of moderate cost (about $200). This portable machine was expected to be able to freeze forty bottles of water per hour. A successful machine of this character would be exceedingly useful at many of our military posts. Mr. Gillet has promised to inform me so soon as one of them is ready for examination, and I have postponed any further investigation until that time.

In concluding this report, I may remark, probably the event of greatest interest and importance to medical men during the exhibition

was the meeting of the International Medical Congress, which met at Philadelphia in September. This congress was attended by a number of physicians and surgeons from abroad, among them not a few of eminence and ability, and the medical profession of our own country was also well represented. The Medical Department of the Army was invited to send delegates, which was done by the authority of the honorable Secretary of War.* The discussions of the congress were interesting, and some of them of considerable value. I shall, however, refrain from giving any account of them in this report, because a volume of transactions, in which they will be fully reported, is at this time going through the press. The attendance of foreign medical men at this congress would of course have been much larger if it had been possible to reunite at any one time all those who visited the exhibition during the season. Many distinguished visitors were obliged to leave before the sessions of the congress commenced. I am happy to be able to report that almost all these gentlemen visited the Hospital of the Medical Department of the Army at the Centennial grounds, and examined the objects there exhibited. I may add that a very large number of American physicians did the same, and that in all over 7,500 physicians and surgeons registered their names at the hospital during the Exhibition.

I have the honor to be, very respectfully, your obedient servant,

J. J. WOODWARD,

Surgeon, U. S. Army, and Brevet Lieut. Colonel.

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*The delegates were Surgeons J. R. Smith and J. J. Woodward; Assistant Surgeon J. S. Billings attended as a delegate from the Public Health Association, and Assistant Surgeon G. A. Otis as a delegate from the American Medical Association.

APPENDIX A.

NOTES ON SURGICAL INSTRUMENTS AND APPLIANCES, AND MEANS OF TRANSPORT FOR WOUNDED, OBSERVED AT THE INTERNATIONAL EXHIBITION AT PHILADELPHIA IN 1876.

By GEORGE A. OTIS, *Assistant Surgeon, U. S. A.*

At the request of Surgeon J. J. Woodward (charged with the representation of the United States Army Medical Department at the Centennial International Exhibition at Philadelphia of 1876), in the concluding week of the Exposition I looked over such contributions as related to surgery, and made notes of those that pertained more especially to army surgery, including the transport of wounded, and have prepared the following memoranda from these notes. Directed by the commissioner's classification, I sought for exhibits in the four classes (275–278) allotted to surgery and prothesis, and among the vehicles in classes 293, 294, Group XVII. I regretted to find that objects pertaining directly or indirectly to surgery were not numerous, and that those presenting any novel features were few indeed. The objects noted will be mentioned for the most part in geographical order, commencing with the exhibits of the Eastern nations. Few require extended comment.

In the collection of the imperial Japanese commission were sets of instruments for various operative procedures, including dental surgery, made by Y. Nara, of Kioto. They were rude imitations of European patterns, but in number and variety afforded an adequate armamentarium. Mr. Riku-gunsho, of the imperial war department, displayed a variety of hand litters and two-wheeled litters for the transportation of wounded soldiers. From the courteous commissioners it was learned that, with the aid of Dutch teachers, the study of foreign surgical science has been carried on at Nagasaki for the last twenty years, and that since 1872 a medical school had been established at Tokio, where nearly five hundred pupils attended demonstrations and lectures in the German language. From information derived chiefly from this source, Japanese workmen now exerted themselves to produce the various instruments and appliances employed by the best surgeons of the Western countries. The means of transport for wounded had been constructed under the supervision of the war department, to answer the necessary requirements as well as the state of the roads and facilities for transportation in the country would permit. The hand-litters, consisting of stretchers of a light, strong textile fabric resembling canvas,

extended on bamboo poles, constituted a happy adaptation of the resources of the country. They were of the simplest construction. Long sides poles of bamboo were passed through a hem or loops in a sacking-bottom and kept apart by traverses of bamboo. The lightness, elasticity, and strength of bamboo especially adapt it for use for litters, and conveyances for the sick and wounded constructed of it have long been held in the highest esteem by British medical officers serving in the East. Litters constructed after the pattern of the Bombay and Madras dhooleys afford such an easy and serviceable mode of transport for wounded men that their introduction into the military service of the Western nations has repeatedly been advocated. In Japan and in India, two trained bearers readily transport a man of ordinary weight for a considerable distance, with surprising ease, rapidity, and endurance. The want of such a class of trained bearers has been the obstacle to the introduction of this excellent means of transport for the sick and wounded in Europe. The two-wheeled litters exhibited by Mr. Riku-gunsho were designed for the transport of one or of two wounded men in a sitting or semi-recumbent posture. The first appeared to be a modification, but not an improvement, of the wheeled litter of Gablenz, and the second, for two patients, resembled that proposed by Dr. Neudörfer, of the Austrian army. They did not compare favorably with the German regulation field wheeled litter, or the Gauvin wheeled spring stretcher, or with that constructed by Neuss, of Berlin, for the Johanniter Order, and reproduced with modifications by Lieut. Col. C. H. Tompkins, U. S. A. Military surgeons are now generally agreed that the best forms of wheeled litters, while affording exceedingly easy and comfortable transport for wounded soldiers, with rapidity of movement and economy of labor, are yet unsuited for general service in armies, because their complexity and high cost precludes their issue in sufficiently large numbers, or their compact packing for distant transport.

In the Chinese collection, under the head of "Medicine, surgery, and prothesis," there were exhibited by the Imperial Maritime Customs specimens of seven hundred and fifty-six drugs and one set of surgical instruments. The commercial value and the real or supposed one of the drugs in Chinese pharmacy were indicated by labels. Many of these drugs are employed, according to these statements, in surgical affections. The variety of applications, mineral, vegetal, and animal, for wounds, ulcers, piles, sore eyes, gonorrhœa, stricture, hæmorrhages, and cancer, was astounding. In the case of plants and chemical compounds the officinal names of the objects were sometimes recorded; but in most instances popular names conveyed no suggestion of the nature of the drug. The accounts given of their therapeutical applications appeared to be drawn by those who regarded the Chinese practitioners with unfriendly eyes. The most costly medicines were a peculiar kind of ginseng (root of *Panax ginseng*), a tonic panacea, valued at $7,000 per catty. Camphor is said to sell at Ningpo for $30 per pecul, while "glue

from tigers' claws," an esteemed tonic, commands at the same emporium $1,500 per pecul. It was noticeable that almost all the remedies for syphilis were based on some mercurial ingredient, and that the itch-medicines were compounded with sulphur. Possibly, if the Chinese doctors could interpret themselves, they would appear less absurd to the outer barbarians. The collection "No. 4546, Surgical Instruments, value at Amoy $3.50," was appraised at its full worth.

In the collections from the British Indian Empire and from Siam nothing relating to surgery was noticed, and the same may be said of the interesting exhibit from the Spanish colonies in the Philippine Islands. The latter contained, however, three Malay crania, contributed by D. Federigo Prieto, of Tabaco, Albay. Two of these skulls, through the kindness of Col. Juan J. Marin, chief commissioner, were presented to the ethnological section of the Army Medical Museum, where they are numbered 1592 and 1593 of Section IV.

In the Egyptian section, Mr. Zucchinetto, of Cairo, displayed a collection of veterinary instruments of no special novelty or interest, save that they constitute the only surgical contribution to the section. There was nothing surgical in the exhibits of Tunis and Algieria, or in those of Mauritius, Cape Colony, the Gold Coast, and other British dependencies in Africa, or in that of the Orange Free State.

In the Turkish section, aside from an interesting exhibit of opium, rhubarb, scammony, and other noted indigenous drugs, crude or manufactured, the only objects specially pertaining to surgery was a series of excellent ebony crutches, made by Abazar Ketour, of Diabekir, suggestive of the oft-repeated prediction that the Ottomans are on their last legs.

In the large Russian section, there was a creditable effort at representation in the classes devoted to surgery and prothesis. Mr. A. Eberman, of St. Petersburg, exhibited a good collection of instruments for urethral surgery, comprising many of the latest forms of urethrotomes, dilators, divulsors, bougies, sonds, &c. The Chirurgical Instrument Manufactory exhibited a large collection, including the instruments for amputation, resection, dental, opthalmic, and general operations used in the Russian army, together with the field-companions, knapsacks, panniers, which make up the equipment of the medical officer in the field. The instruments were well made and of good patterns. The admirable cases of Russian leather attracted much attention. The regulation patterns were similar to those in a full series of this armamentarium presented a few years since to the Army Medical Museum, through the gracious liberality of General Kosloff, the director of the medical staff of the Russian army. Dr. Wyvodzef, of St. Petersburg, exhibited his ingenious syringe and other appliances for embalming by the use of tymol, whereby the soft tissues are preserved in a flexible state, and with little discoloration. This instrument was left by this excellent army surgeon in charge of Mr. Tiemann, for presentation to

the Army Medical Museum. A good veterinary case, and endoscopes, with large mirrors, for the rectum and vagina, imitated from patterns by Weiss, Ricord, Segalas, and Cusco, were exhibited by Mr. J. Pick, of Warsaw. Mr. C. Bauch, of St. Petersburg, exhibited artificial teeth, with apparatus for cleft palate and deformities of the jaws. Dr. Berkmeier, of Moscow, displayed a similar collection. Dr. Finkbeiner, of Revel, presented rubber appliances for stammerers, and for the rectification of irregular teeth. Mr. T. Ivanhoff, of St. Petersburg, sent a photograph of an ambulance cart with its appurtenances, of his invention. I could not learn its weight and dimensions, but it appeared to be cumbrous, with the defects that seem to be unavoidable in two-wheeled vehicles for the transport of wounded. Steps for ambulance carts, and springs for litters, exhibited by Lilpop, Rau, and Loevenstein, of Warsaw, were ingenious, but inapplicable to the methods of wheeled transport in use in our Army. A hand litter invented by General Blassof, and exhibited by Pick, of Warsaw, was strong and serviceable, but scarcely solved the difficulties accompanying the apparently simple, but really most difficult problem of a field litter for general service. Lastly, the Russian war department exhibited a fuller-sized sample of their recently adopted regulation ambulance wagon. It is a two-horse four-wheeled wagon, designed to carry four recumbent patients, and another seated with the driver on the box. The ordinary field-stretchers are used as litters. They are not unlike the old United States Army or Satterlee pattern; but the two resting on the floor of the wagon are supplied each with four springs of the pattern devised by Grund, of Berlin (Fig. 1).

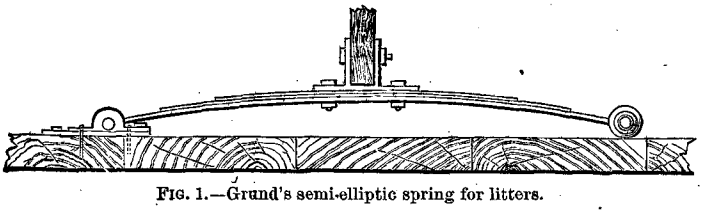

FIG. 1.—Grund's semi-elliptic spring for litters.

Two other litters are suspended from the hoops of the wagon-top by elastic rubber rings of the American or Harris system. The wagon is strongly built, and well supplied with lanterns, water-kegs, and the driver's necessary outfit for the care of his horses. The body is not unlike the Wheeling wagon; the running gear is heavy; the front wheels do not traverse, or turn under the body, to permit the vehicle to turn on its own ground. This instructive ambulance wagon, with its appurtenances, was presented, by direction of Chief Commissioner Keratry, to the United States Army Medical Department, by Professor John Charles Heard, one of the imperial commission. It is now stored at the Soldiers' Home, at Washington.

In the Swedish section was exhibited a full-sized sample of an army

medicine wagon, very substantially built of oak, and handsomely finished. It was fashioned something like a caisson, with double shafts for two horses. The front wheels turned under a capacious driver's seat, with a large receptacle for forage, lanterns, lariats, water casks, buckets, brushes, and other furniture. There were doors on the sides and rear of the body of the wagon, opening into closets, provided partly with drawers and partly with compartments and hampers in which were stored a writing desk, sacking bottom for stretchers, tin splints, a supply of medicines, cordials, anæsthetics, dressings, instruments, and appliances, ample for a regiment in a campaign. There was no explanatory pamphlet, but from a portfolio of photographs of vehicles used in the ambulance service of Sweden and Norway, sent by Dr. Nicolaysen, of Christiania, I infererd that this sample represented the brigade wagon for medical supplies in use in the Swedish army. The sanitary department of the royal war office at Stockholm exhibited a set of surgical instruments for military use. The cutlery was excellent, but the outfit of instruments would be esteemed by most field surgeons somewhat restricted. Surgical instruments of good finish were exhibited by Mr. A. Stille Eskilturn, of Stockholm. In the Norwegian collection I observed nothing pertaining to surgery or medicine, except cod-liver oil, and, in the Danish section, nothing whatever.

In the Netherlands section, an interest in a method of much value in military surgery was manifested by a display of the latest improvements in the application of plaster of Paris dressings for fractures, and especially of such modifications as adapt these dressings for immediate use in shot fractures. Twenty appliances were exhibited by Dr. A. Mathijsen, a senior surgeon of the staff of the Netherlands army. This series afforded dressings for every description of fracture involving either the joints or continuity of the long bones of the upper and lower limbs. The dressings were made of strips of coarse flannel, to be rubbed, on both sides, with dry finely powdered gypsum, and then rolled loosely and laid in water for a few moments prior to application. The surface of the injured limb should be well anointed to prevent the adhesion of the hairs to the plaster, or a preliminary muslin spica bandage may be placed on the limb with scrupulous accuracy, and the plaster dressing applied over this. When the plaster strips are applied, it is well to surround them with a neatly applied muslin roller bandage; and often, especially in the large dressings for injuries of the thigh or knee-joint, it is desirable to reinforce the first layer of plaster dressing, before the outer bandage is applied, by longitudinal or transverse strips of flannel, or blotting-paper, or silk taffety, and to continue over these the plaster bandage, so that the plaster-case may become sufficiently firm. When the plaster has set and become quite hard, fenestra can be cut over the seat of wound, to make it accessible for local dressings; and the entire case may be devided into two segments, by longitudinal incisions, so that the appliance can be readily removed and reapplied. It was noted,

as adding to the value of these appliances, that they had all been actually applied to cases of the various accidents they are designed to treat. An ingenious pair of scissors, devised by Dr. Mathijsen, accompanies the exhibit, as well as versions in several languages of his well-known pamphlets: *Du bandage plâtré, et de son application dans le traitement des fractures*, Haarlem, 1852; *Traité du bandage plâtré, etc.*, Paris, 1859; *Abhandlung über den Gypsverband*, Leipzig, 1870. Dr. J. P. H. Van de Loo exhibited a "Plaster Paris Impressor," and a number of gypsum bandages for the limbs, regarded as a simplification of the Mathijsen system, and a copy of a treatise on "the immediate amovo-inamovible plaster dressing." Dr. W. Krol, of the army of Holland, also exhibited a little work on the plaster of Paris dressing, with models illustrating the Mathijsen system. The various models above referred to were presented to the Army Medical Museum, at the request of the exhibitors, by the eminent president of His Netherlands Majesty's commission at the International Exhibition, Dr. Professor von Baumhauer, of Haarlem, secretary of the Dutch Society of Science, &c. Sets of the publications of the Netherland society for the aid of sick and wounded in war, and of M. W. C. Gori, of Amsterdam, on the objects relating to military surgery and sanitary service exhibited at Vienna in 1873, were included in the Dutch collection, and were politely donated to the library of the Surgeon-General's Office.

In the Belgian section, Dr. H. Guillery, of Bruxelles, contributed appliances for primary dressings for battle-field injuries or railway accidents. Among these were neat splints of perforated malleable metal susceptible of being molded to the shape of limbs, and a pamphlet on the policing of the battle-field of Sedan. Surgeon E. Hermant, of the First Mounted Chasseurs, sent six copies each of two illustrated pamphlets and of a *vade-mecum* for military surgeons. These works were entitled: 1. *Nouveaux modèles de sac d'ambulance et de sacoches à médicaments, adoptés dans l'armée belge.* 2. *Essai sur l'organisation des ambulances volantes.* 3. *Aide mémoire du médecin militaire*, 12 mo. pp. 500. Dr. V. Hollsbeck, of Bruxelles, sent two works on army surgery, or sanitary service: *Souvenir de la guerre franco-allemande, au point de vue chirurgical*, and *La Croix Rouge.*

In the French section, Vitry frères, of Paris, exhibited a large collection of handsomely finished surgical cutlery. The famous makers, Robert et Colin, Luer and Mathiew, were not represented. M. Bènas and MM. Vergne et Chose, of Paris, sent assortments of gum-elastic catheters, bougies, and other urethral instruments. Rondeau frères, of Paris, exhibited surgical appliances of rubber, and trusses of good pattern and workmanship. Rigollot et Cie., of Paris, sent samples of sinapisms and of readily prepared poultices, prepared of a composition of sea-weed, which, immersed in hot water, swell up and afford an improvised cataplasm. Limousin, of Paris, contributed an apparatus for inhaling oxygen gas.

In the exhibit of the United States Army Medical Department Gauvin's wheeled litters, and the field operating cases of the French army surgeons, made by Charrière, were displayed.

In the British section of the exhibition there was nothing noteworthy relating to surgery. F. C. Rein, of London, presented some specimens of trusses, a variety of bougies and catheters, various elastic contrivances for deformities, and crutches, elastic stockings, and electro-magnetic machines. Lang, Jonas, and Jules displayed a variety of rubber surgical appliances that had been rewarded at Vienna. Lynch & Co., of London, exhibited atomizers and apparatus for special deformities. Mayer and Mettzer, of London, sent specimens of surgical cutlery and galvanic apparatus. The famous British manufacturers of surgical instruments, Weiss, Coxeter, &c., were conspicuous by their absence, and there were no contributions from the military medical school at Netley, where great attention has been paid to the surgical material requisite in any service and especially to the means of transport for the wounded in war. There was an equal paucity of surgical contributions in the exhibits of the British colonies. This subject was illustrated in the collection of New South Wales only by dental instruments sent by J. Spencer, of Sydney; in the Victoria exhibit, by models of invalid chairs, devised by Stanway, of South Yana; in the collection of the Cape of Good Hope, by the bitter barks used by the Kafir doctors; in the Jamaica collection, by straps for sharpening cultery made from the stems of plants. In the exhibits of Bermuda, the Bahamas, Guiana, Ceylon, Queensland, Trinidad, New Zealand, South Australia, and Tasmania, by nothing that could be strictly construed as pertaining to surgery.

In the Swiss section, a collection of lint bandages, gauze, and other accessories for the antiseptic dressing of wounds were exhibited by M. Batschlin, the director of the renowned establishment at Schaffhausen, which produces, of excellent quality, on a very extensive scale, all the articles requisite for minutely carrying out the antiseptic method of operating and dressing devised by Professor Lister, now largely employed in Germany and some other parts of Europe. Professor Lister was present at the International Medical Congress held at Philadelphia during the Centennial Exhibition, and demonstrated to the surgeons there assembled the practical application of his system. It is to be regretted that the exorbitant prices charged in this country for the Edinburgh atomizers used in this method seem likely to impede the popularization of a system based on the most careful inductive inquiry, and probably constituting the most important advance in surgery since the introduction of anæsthetic agents.

There were more contributions pertaining to surgical or sanitary appliances in the German section than in any other of the foreign collections. Prof. F. Esmarch, of Kiel, sent specimens of his famous appliances for bloodless operations. The elastic bandage of rubber, woven with red worsted webbing, the stout chain and tubing of non-vulcanized

rubber, were more durable and substantial than the imitations that have been manufactured in this country. The triangular scarf, stamped with figures illustrating its various applications, the little compresses with charpie and waxed paper for primary dressings, a simple field pocket-case, an apparatus for chloroform inhalation in the field, and an elastic appliance for extension for fractured femur (when it is imperative to transport the patient to a distance), were among the objects which received a diploma of honor at the Vienna Exposition of 1873, and were selected for exhibition by this eminent inventor, who has so largely promoted the improvement of field surgery in the last quarter of a century. I regretted that Professor Esmarch did not include his simple and excellent splint for the after-treatment of excisions at the elbow-joint. The surgical clinic of Königsberg, Dr. Schönborn, director, sent gypsum hempen bands for the treatment of fractures and diseases of the joints, devised by Assistant Surgeon F. Beely, with photographs

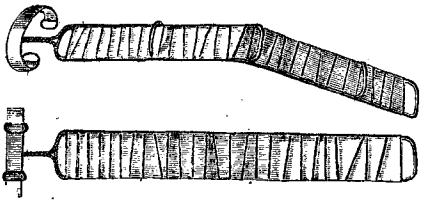

FIG. 2.—Port's wire splint for the upper extremity.

illustrating their application. They appeared to be a cheap, convenient, and satisfactory modification of the plaster dressing. Staff-surgeon Julius Port, of Munich, exhibited a system of splints for shot fractures, based on the utilization of telegraph wire, now almost always available whenever an army moves against a civilized enemy. Strong pliers are pro-

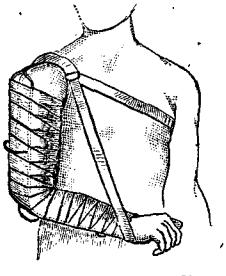

FIG. 3.—Port's arm splint applied.

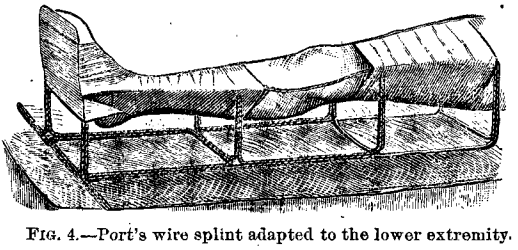

FIG. 4.—Port's wire splint adapted to the lower extremity.

vided by which the wire is bent into the form of Smith's contusion splint, or Hodgen's apparatus, or of suitable cradles for either the upper or lower limbs. Roller bandages and plaster suffice to complete the apparatus. The forms of splints most commonly required for the upper and lower extremity and their application are shown in the accompanying wood-cuts Figs. 2, 3, 4. When the apparatus is used for a fracture of the femur,

Dr. Horn adds a retentive apparatus of willow twigs. This system, based on a principle the military surgeon should ever have in view, of utilizing the material on hand, is worthy of all commendation. With moderate ingenuity G. Horn, of Kiel, sent an assortment of very good carved wooden splints. In treating some chronic affections of the joints particularly, these splints are preferable to any others. This exhibit was accompanied by a certificate from Professor Esmarch, recommending Mr. Horn as "an honest and ingenious workman." Dr. Bernard Beck, of Carlsruhe, sent a highly interesting set of improved field appliances. In the first place a litter (Fig. 5) composed of seven slats of inch pine 6 feet long and 2½ inches in breadth, fastened to two traverses of the same material 24 inches long, by means of cords woven of straw repeatedly interlacing the slats. On this is laid a pallet of wheat straw, also secured by the woven straw cord, and a bundle of straw at each end furnishes a pillow and a foot piece. These bar litters are designed

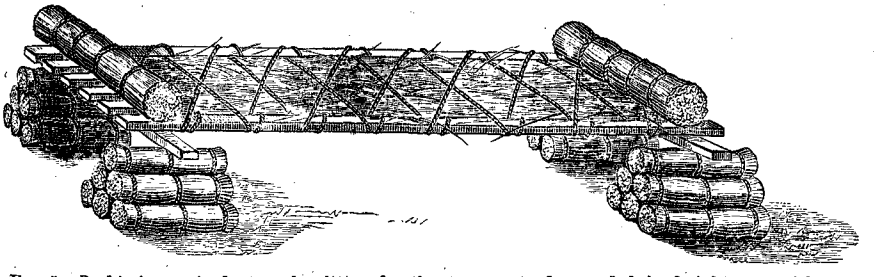

FIG. 5.—Beck's improvised straw bar litter for the transport of wounded in freight-cars without springs.

to be used in pole-wagons or freight-cars without springs, and to be suspended on hooks and anchored to the floor below. There are also provided double inclined planes or straw wedge pillows, composed of six bundles, each 14 inches long and 3 inches in diameter (Fig. 6), tightly bound together by the woven straw cord. These serve either for supporting the limbs or trunk in comfortable positions, or if facilities for suspending the litter are not available, four of them may be placed, one under each corner of the litter, to deaden the shock in a supply wagon or freight-car unprovided with springs. Accompanying the litter is a supply of splints or mats of straw bound together by twine and of suitable dimensions for application to the thigh, leg, arm, and forearm. Batons of straw of different length and combined in various ways are made to afford the requisite support to the injured limb. There is also a willow splint for use in fractures of the lower limb. The outfit constitutes a serviceable provision for the transport of a gravely wounded man, improvised upon the simplest materials. No nails are used, but a comfortable couch with dressings is made of slats of wood, straw, and twine. If, in Dessault's phrase, the simplicity of an apparatus is the measure of its perfection, the conditions are realized in this ingenious device. From Carlsruhe there was also a model of

one of the members of the volunteer aid society, in uniform and fully equipped. The dress consisted of a pasteboard helmet, a gray long-skirted coat with black facings, black trousers tucked into long boots, a black cloth overcoat and thin rubber overgarment, a white half chevron on the left arm with the red Geneva cross, and woolen underclothing. The equipment comprised a knapsack, with the infirmarian's change of

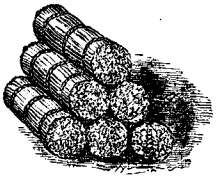

FIG. 6.—Beck's wedge-shaped straw pillow.

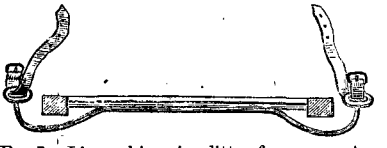

FIG. 7.—Lipowski spring litter for suspension

clothing and a pocket for field dressings, a tin box to serve both as a dish and for cooking, a flask for spirits, a set of Esmarch's field dressings, and a shoulder-strap to support the handles of a litter. A. Moratzky, manufacturer of gypsum dressings at Neubuckow, sent an assortment of his goods. P. Hartmann, of Heidenheim, and the Chemical Factory at Helfenheim, also sent samples of surgical dressings. L. Müller-Uri, of Lauscha, displayed an assortment of artificial eyes, human and animal. He has been long engaged in this specialty, and his work received a premium at the Vienna Exposition. E. Lipowski,

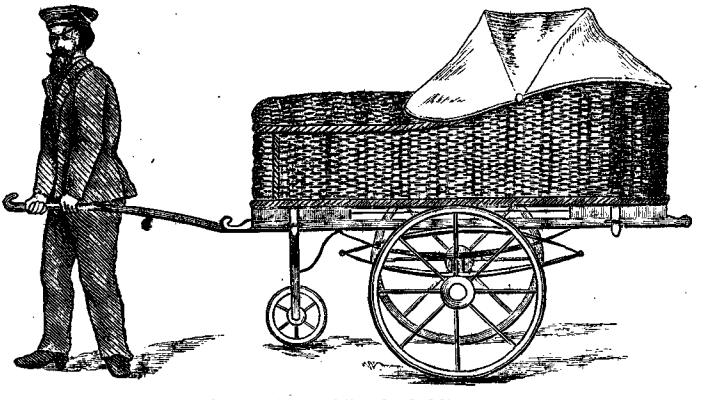

FIG. 8.—Lipowski's wheeled litter.

of Heidelberg, exhibited a variety of invalid chairs and beds, operating chairs and tables, furniture for the sick room, and a series of litters for army service. There were several field hand-litters arranged after the German fashion to place the patient in a semi-recumbent position by elevating the head and shoulders. They threw no light on the difficult problem of a litter at once light, serviceable, inexpensive, and adapted to the various exigencies of field service. One was designed for suspension in transport in ambulance wagons or on railway. It consisted of a canvas-sacking bottom, with side poles and

wooden traverses terminating in blocks at the ends, which rested on curved steel springs (Fig. 7) fastened by leathern straps to hooks on the stanchions of a carriage. This is only a variety of one of the earlier and discarded means of suspending litters, and would infallibly be attended with too much oscillation of the litter. There were two wheeled spring litters (Figs. 8, 9), one furnished with a basket hamper for clothing, and a cover for the litter. These appeared to me quite as complicated and not more serviceable than the wheeled litters of Neuss, of Berlin, and Fischer, of Heidelberg—not represented at the Exhibition.

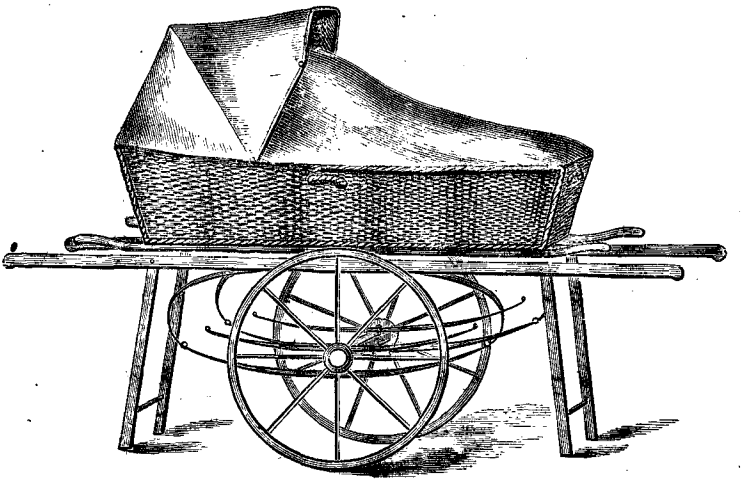

FIG. 9.—Lipowski's field litter.

The latter have been employed to a considerable extent on the battle-field, and are perhaps the best of their kind; but in actual service this class of vehicles are unsatisfactory, or of limited application. M. Lipowski sent also wire splints in great variety, and altogether a large and interesting collection. The directors of the Lower Silesian and

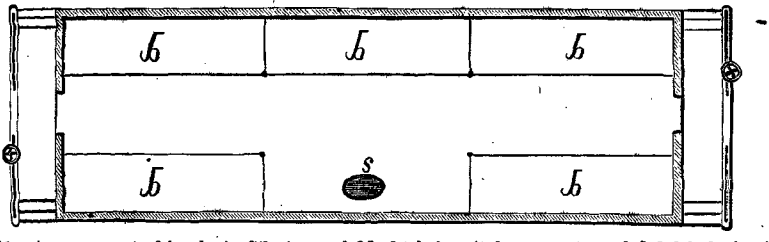

FIG. 10.—Arrangement of bunks in Silesian and Markish hospital car; *s*, store; *b b b b b* the bunks.

Markish Railway exhibited two handsome models of hospital cars, one for the sick and wounded, and one a kitchen car, the latter provided with a range, cooking utensils and supplies, one ice-box, &c. The models were made with glass roofs, to display the interior fittings. The car for sick or wounded was fitted up with ten bunks in double tiers (Fig. 10). The litters have movable head rests with a rack adjustment, and

are suspended from upright stanchions, each by four springs of the kind M. Lefort proposed as a substitute for the rubber rings introduced by Dr. Harris, which rendered such good service in America and in Ger-

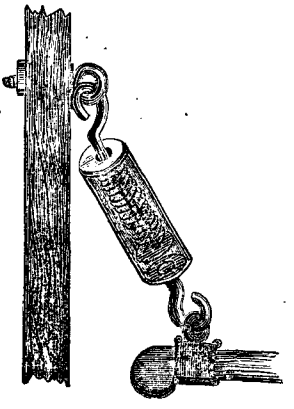

FIG. 11.—Spring for suspending litters.

many. The sanitary train illustrated by these models was constructed at Frankfurt-on-the-Oder. Sets of drawings of a complete hospital railway train accompanied the models. The directors also exhibited a model of a litter with arm rests.

Mr. N. Plambeck, of Hamburg, exhibited a model of a freight car converted to hospital purposes. This system, which has been described by Staff Surgeon Löwer (*Deutsche Militairärztliche Zeitschrift*, 1872, B. I, S. 143), rendered most efficient service during the Franco-German war. A train would leave Hamburg consisting of a passenger car for the surgeons and attendants, and three or four box freight cars filled with litters, bedding, stoves, fuel, cooking and eating utensils, provisions, chests of bandages and appliances, and medicines; supplies ade-

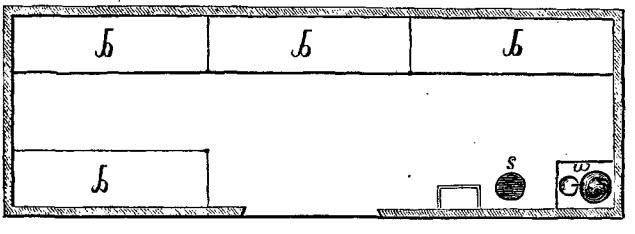

FIG. 12.—Hamburg hospital freight car. Floor plan placed.

quate for a hundred and sixty patients. At the seat of war empty freight cars that had carried forward ammunition and supplies would be found and hastily fitted up to serve as hospitals. Eight litters were usually placed in a car. (Fig. 12.) Six, in two tiers, occupied one side of the car, and two were placed on the other. The wide side door afforded easy ingress to patients borne on litters. The upper tiers of lit-

ters were suspended by the claw (Fig. 13) devised by Mr. Hennicke. The lower litters hung by springs from wooden frames. The arrangement is by no means the best that can be devised, but it is of ready application, and under good supervision proved a most valuable means of improvising comfortable accommodation for the sick and gravely wounded. Numerous publications, for the most part well known, on sanitary appliances and on the Geneva Convention, were sent with the

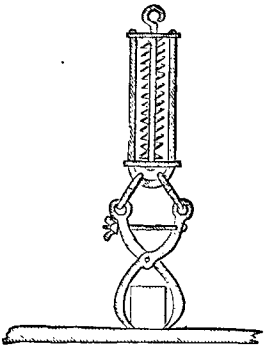

FIG. 13.—Hennicke's claw and spring for suspending litters.

German exhibits. There was also exhibited by Her Majesty the Empress of Germany a sample of the case carried by each German officer and soldier on campaign, containing an assortment of Esmarch's primary dressings, scissors, finger cots, &c., with a copy the little "Help one's self" Schaafhausen manual.

In the Austrian section, pure sulphuric ether was sent by Pollok, of Vienna; trusses by Hamerli, of Funfkirchen, Hungary; plaster of Paris fracture dressings, by A. Zaigmondy, of Vienna; artificial teeth by Berghammer, of Vienna, and Port, of Kiansenberg, Hungary; and Dr. Adam Politzer, of Vienna, sent an exquisite series of anatomical demonstrations of the ear, which I was glad to learn was acquired by the Museum of the College of Physicians, of Philadelphia, and retained in this country.

The display of surgical instruments and appliances in the Italian exhibition was meager. Morreale, of Palermo, exhibited an *acqua emostatica* among the pharmaceutical preparations; Menici, of Livorno, an invalid bed, "macchina per sollevare i malati"; Papini, of Florence, a truss; Bernabei, of Rome, an enema syringe; and the Cavaliero Gennari, of Milan, a collection of surgical instruments, comprising those used in general surgery, and those for ophthalmic operations, a series that had been honored by medals at Naples and Milan, and by a medal of merit at the Vienna Exhibition of 1873. Gramignani, of Ancona, Testi, of Bologna, and Sirletti, of Rome, sent dental implements and artificial teeth. Nothing was found in this section suggestive of improvement upon well-known patterns.

In the general Spanish collection in the classes relating to surgery and sanitary material, there were displays of artificial teeth by dentists of Seville and Coruña, uteroscopes and vaginal speculæ by makers in Madrid and Cadiz, a blepharotome for operations on the eyelids, devised by Dr. Gastaldo, of Madrid, together with samples of Ojero hæmostatic, Zaragosa water, ratafia, and other restoratives and styptics. But more interesting to the military surgeon were the appliances for field service sent by the medical staff of the Spanish war department. These comprised a number of field litters and cacolets, very simple and serviceable, pack saddles and panniers, a hospital knapsack, a case of splints and surgical dressings, together with small models of mules packed with litters, cacolets and panniers. Two field litters were constructed of iron-tipped round side-poles, 8 feet long and 1½ inches in diameter, kept asunder by iron frames serving as traverses, and supplied with legs, that at the head (Fig. 14) having also a bow for the attachment of an oil-

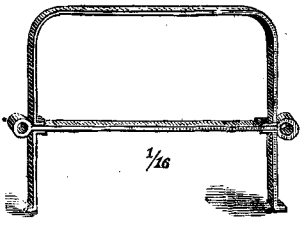

Fig. 14.—Iron traverse with rings, bow, and legs.

cloth cover to protect the patient from the weather. Canvas stretchers were looped to the side poles, and also to the headpiece, so as to elevate the head and shoulders. Each litter was supplied with a pair of hospital blankets and with shoulder-straps of webbing for the bearers. The chest of splints and bandages contained a full assortment of appliances for dressing fractures and wounds of the joints in the upper and lower limbs, the apparatus for fractures of the lower limbs resembling the Amesbury and McIntire patterns, once much used in Great Britain. I was particularly interested in the full-sized pack saddle and panniers, and in the small models of saddled mules carrying panniers, litters and cacolets. Recent experience of our own Army, in the Modoc country and in the Black Hills, has demonstrated that the Army Medical Staff in certain exigencies must rely mainly on this mode of transport for its supplies and its means of affording succor to the wounded. It would be tedious to recite the instructive details in the equipment of pack animals that were easily understood by inspecting these Spanish models. But I make careful notes of them for reference by medical officers.

In the exhibit from Portugal, I noticed nothing more nearly related to surgical appliances than the hones and whetstones contributed by Manilha, of Valongo.

In the Brazilian exhibit, under the head of surgery and prothesis, there was a display of artificial teeth by dentists of Rio de Janeiro, and

a collection of surgical instruments by Merino & Co., of French patterns. The only novelty I noticed was an electrolytic probe for detecting metallic foreign bodies, the invention of Dr. Fragoso, somewhat resembling the electric explorer of Trouvé. A complete series of the *Annæs Braziliensis de Medecina*, a monthly journal published at Rio de Janeiro for thirty years past, contained some valuable contributions on operative surgery.

The articles relating in any way to surgery included in the representation of the Argentine Republic, consisted of plaster of *arnica montana*, from Corrientes, artificial teeth from Buenos Ayres, and a set of orthopædic appliances, made by Lacour, of the latter province. In the exhibits of the other South American countries represented, Chili, Peru, and Venezuela, nothing surgical was found.

Passing to exhibits from North America, in the Canadian section were specimens of artificial limbs, trusses and elastic bandages from a Montreal factory. These, in workmanship, were hardly of the first order. In the Mexican section, A. Rogul, of Mexico, and Chacun, of Mariana, sent specimens of artificial teeth.

In the United States section the principal makers of surgical instruments and appliances were well represented. Their products are too well known to American surgeons to require detailed comment. The old and reliable houses of Tiemann & Co., Shepard & Dudley, and F. G. Otto & Sons, of New York, D. W. Kolbe and J. H. Gemrig, of Philadelphia, and Codman & Shurtleff, of Boston, made exhibits that demonstrated the great advance in the art accomplished in this country in the last quarter of a century. The patterns were generally of the most approved forms, the workmanship little inferior to that of the best makers of London and Paris. The variety of instruments required by the ophthalmic, aural, laryngeal, rectal, urethral, vesical, and gynecological specialists was surprising. Some of the American modifications and improvements were really original and valuable; yet it was unpleasant to observe many reproductions of well-known inventions of English and French surgeons, with some trivial alterations, dubbed with the names of American specialists. Besides the older makers, Messrs. G. P. Pilling, H. G. Kerr, and J. J. Teufel, of Philadelphia, and M. Leiner, of New York, exhibited surgical cutlery and apparatus. The display of splints and other fracture appliances was large. The principal exhibitors were G. H. Day, of Bennington, Vt., J. T. Woods, of Toledo, Ohio, J. M. Rhodes, of Hancock, Mich., the "National Surgical Institute" of Indianapolis, Atlanta, Philadelphia, and San Francisco, Handy and Boland, of Atlanta, Ga., and Dr. David Ahl, of Newville, Pa. Tiemann, Kolbe, Gemrig, and other general furnishers of surgical apparatus also exhibited fracture appliances. It was noticeable that the plaster of Paris method has apparently found little favor with American dealers. Some of the contrivances for elastic and weight extension of the lower limb were very good. The porous felt splints of

Dr. David Ahl are deservedly held in high estimation. I know of no better substitute for the gypsum bandage. They are easy of application, and are well adapted to field service.

The profuse display of crutches and of artificial limbs testified to the impulse given to these branches of manufacture by the late war. B. F. Palmer, J. P. Bethel, D. W. Kolbe, R. Clement, J. A. Foster, B. C. Everett, W. Blanck & Son, of Philadelphia; E. D. Hudson, C. A. Frees, A. A. Marks, J. Condell & Son, of New York; L. F. Pengree, of Portland, and the National Surgical Institute of Indianapolis and elsewhere, were the principal exhibitors of artificial limbs. Many of the specimens were of the highest order of excellence. Mr. J. A. Foster, of Philadelphia, accompanied his exhibit by photographs of several subjects amputated in both lower limbs. Mr. B. F. Palmer's exhibit was illustrated by a catalogue showing the vast number of sufferers supplied with the limbs devised by him. Messrs. Kolbe, Clements, and others, furnished pamphlets with explanatory drawings and descriptions of the adjustments and improvements peculiar to their several forms of appliances. Dr. E. D. Hudson sent a suitable collection of pamphlets and photographs, and his collection embraced a variety of prothetic apparatus for the after-treatment of excisions, and appliances for the relief of deformities. In his exhibit, the ingenious means for adjusting apparatus after Syme's amputation at the ankle, and after disarticulation at the hip, were remarkable, and vindicated the reputation he has achieved in this branch of mechanical surgery, in carefully and conscientiously modifying his apparatus for adaptation to particular exigencies. Many of the manufacturers above named exhibited orthopedic apparatus, in the extended sense in which the term is made to include not only instruments for the correction of talipes, but for the treatment of spinal curvature, wry-neck, and various diseases and deformities of the joints. Mr. Kolbe's exhibit in this direction was particularly good. Among the exhibits of elastic bandages, laced stockings, and other surgical furniture the tradesman would probably classify as "rubber goods," the skill and ingenuity of the American manufacturers were conspicuous. There was a large display of trusses, including some complicated and highly ornamental and costly patterns. For the treatment of ordinary inguinal hernia, nothing was observed preferable to the old-fashioned Chase truss, a useful invention, of which the patent long since expired. This is made with a wooden pad fastened to a wrought-iron bar, which may be bent so as to secure an accurate adjustment of the pad. It can be manufactured of the best quality, at a very moderate cost, not exceeding $12 per dozen.

THE ENGINEER DEPARTMENT

CAPTAIN D. P. HEAP,

CORPS OF ENGINEERS,

IN CHARGE OF ENGINEER SECTION, WAR DEPARTMENT PARTICIPATION.

OFFICERS OF THE CORP OF ENGINEERS

ON DUTY AT

THE ENGINEER SECTION OF THE WAR DEPARTMENT EXHIBIT, INTERNATIONAL EXHIBITION OF 1876.

Capt. D. P. HEAP. In charge of Section.

*Capt. JAS. C. POST. From September 30 to close of Exhibition.

*Lieut. E. H. RUFFNER. From October 17 to close of Exhibition.

*Lieut. S. S. LEACH. From May 1 to September 9.

The attendants of the Engineer Section were Corporal MARTIN DOOLAN and seven privates from the Engineer Battalion.

Mr. H. L. BROWNE had immediate charge of the model of Hallet's Point (Hell Gate).

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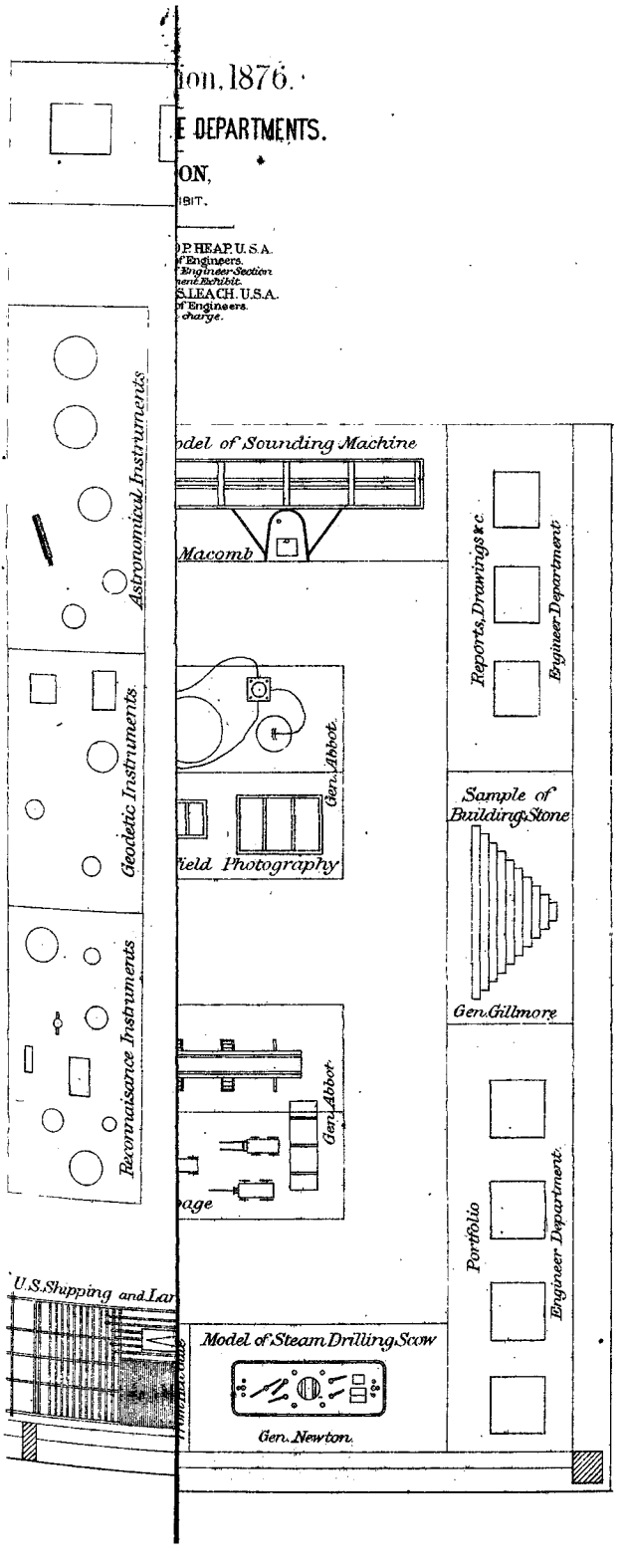
* These officers reported directly to the officer in charge of the Engineer exhibit, for temporary duty, and were not under the orders of the representative of the War Department.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Astronomical Instruments.
Geodetic Instruments.
Reconnaissance Instruments.
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Gen. Abbot.
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Gen. Abbot.
age
Reports, Drawings &c.
Engineer Department.
Sample of Building Stone
Gen. Gillmore.
Portfolio
Engineer Department.
U.S. Shipping and Lar
Model of Steam Drilling Scow
Gen. Newton.

International Exhibition 1876

BOARD ON BEHALF U.S. EXECUTIVE DEPARTMENTS.

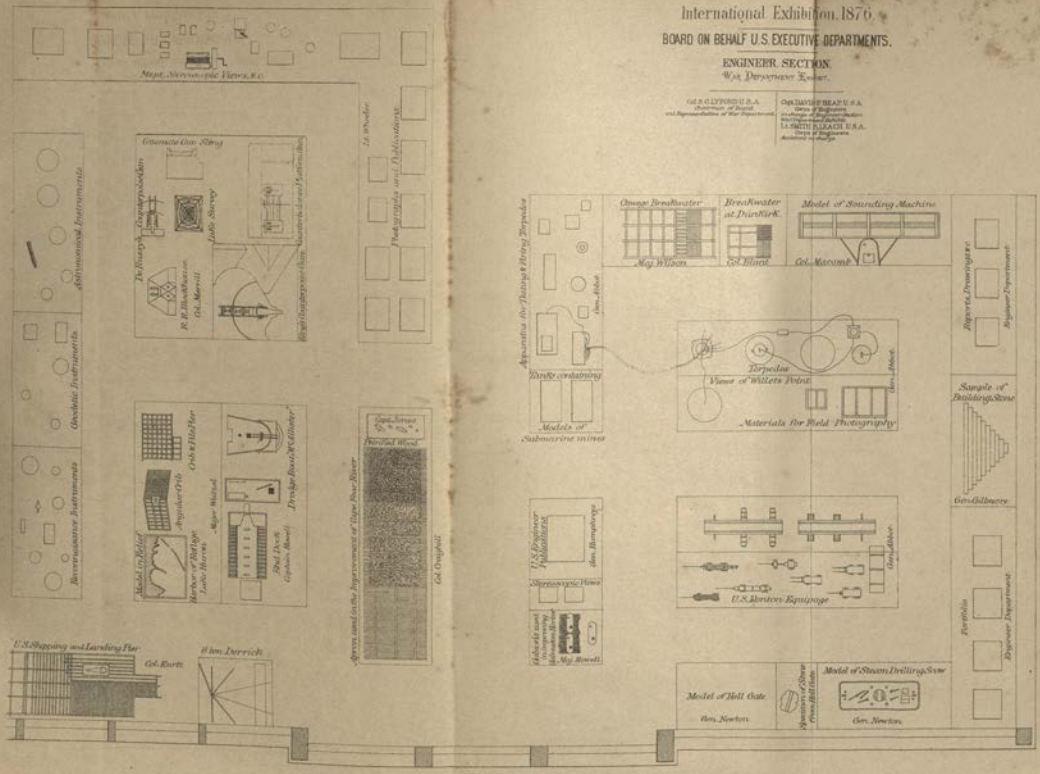
ENGINEER SECTION.

War Department Exhibit.

Col. S. G. LYFORD U.S.A. Chairman of Board and Representative of War Department.

Capt. DAVID P. HEAP U.S.A. Corps of Engineers. In charge of Engineer Section and Executive.

Lt. SMITH S. LEACH U.S.A. Corps of Engineers. Assistant in charge.



WASHINGTON, D. C.,
November 30, 1876.

COLONEL: I have the honor to inclose herewith "Catalogue of the Engineer section War Department exhibit," arranged as desired in circular of June 9, 1876.

Most of the labor of compiling the catalogue was performed by Lieut S. S. Leach, Corps of Engineers, during the hottest of the hot months of the past summer. I am indebted to him for this as well as for much assistance in the administration of the Engineer section.

Very respectfully, your obedient servant,

D. P. HEAP,
Captain of Engineers,
In charge of Engineer Section, War Department Exhibit.

Col. S. C. LYFORD,
Representative of War Department,
International Exhibition of 1876.

ENGINEER SECTION WAR DEPARTMENT EXHIBIT.

In preparing this collection, the attempt was made to exemplify the wide scope of duties assigned to the charge of Engineer officers of the United States Army, embracing the charge of—

The river and harbor improvements of the United States.
The surveys of the Great Lakes.
Explorations and surveys of the western country.
The building of fortifications.
The building of light-houses.
Torpedoes for harbor defense.
Military engineering, &c.

The officers of the Engineer Corps who were in charge of works were asked to send or prepare such models and drawings as would exemplify their works. The following officers contributed:

Brig. Gen. A. A. Humphreys.
Col. J. N. Macomb.
Col. J. H. Simpson.
Lieut. Col. John Newton.
Lieut. Col. Geo. Thom.
Lieut. Col. J. D. Kurtz.
Lieut. Col. C. E. Blunt.
Lieut. Col. Q. A. Gillmore.
Maj. G. K. Warren.
Maj. H. L. Abbot.
Maj. W. P. Craighill.
Maj. C. B. Comstock.
Maj. Godfrey Weitzel.
Maj. D. C. Houston.
Maj. Wm. E. Merrill.
Maj. Jno M. Wilson.
Maj. C. R. Suter.
Capt. W. R. King.
Capt. C. W. Howell.
Capt. W. A. Jones.
Lieut. Geo. M. Wheeler.

These officers have charge of every class of work enumerated above, and the excellence of the exhibit is due to their efforts. Many of them sent descriptions with their articles, and wherever this has been done the officer's description has been used. The following is the classification adopted for the catalogue:

CLASS A.—Maps, drawings, and photographs.
CLASS B.—Astronomical, geodetic, and meteorological instruments.
CLASS C.—Torpedoes, batteries, and electrical instruments.
CLASS D.—Models of engineering works and appliances.
CLASS E.—Counterpoise gun-carriages and platforms.
CLASS F.—Military engineering.
CLASS G.—Miscellaneous.
APPENDIX.—Special description of Lieutenant Wheeler's exhibit.
Account of the commencement of the United States Lake Survey.

HISTORY OF THE CORPS OF ENGINEERS.

The following condensed history of the Corps of Engineers has been kindly furnished by Lieut. Col. Thomas L. Casey, Corps of Engineers:

Upon the breaking out of the Revolutionary War persons were employed and appointed as engineers, by the several colonies, for service with their troops and in the construction of defensive works.

The first chief engineer in an army of the United States was Col. Richard Gridley a half-pay British officer, who served with the Provincial Army in the investment of Boston in April, 1775, and subsequently with the Continental Army, in the siege of Boston until its surrender.

The Corps of Engineers as an organized arm of service in the army was first created by the resolutions of March 11, 1779, and, under the operations of these laws:

Brig. Gen. Lewis du Portail, an officer of the French Royal Corps of Engineers, who as an engineer had been in the service of the United States since the 8th of July 1777, was made commandant of the Corps of Engineers May 11, 1779, and continued in this office until the close of the war, when the corps was discontinued under the general provisions for disbanding the army.

By the act of May 9, 1794, a "Corps of Artillerists and Engineers" was organized, containing four battalions, and on the 26th of February, 1795, Stephen Rochefontaine was appointed lieutenant-colonel commandant of the same.

He was succeeded in this office by Henry Burbeck on the 7th May, 1798.

By the act of April 27, 1798, a second Regiment of Artillerists and Engineers was created and John Doughty was appointed its lieutenant-colonel commandant, June 1, 1798.

He was succeeded 26th May, 1800, by Louis Tousard.

By the act of March 16, 1802, the Corps of Artillerists and Engineers was segregated into a Corps of Engineers and a regiment of artillery, Maj. Jonathan Williams, of the Second Regiment in the Corps of Artillerists and Engineers, being appointed the chief engineer; and the "Corps of Engineers," thus re-established, has had a continuous existence in the army until the present date. Its chiefs, who have succeeded Col. Jonathan Williams, are as follows:

Col. and Bvt. Brig. Gen. Joseph Gardiner Swift, appointed July 31, 1812.

Col. Walker Keith Armistead, appointed November 12, 1818.

Col. and Bvt. Maj. Gen. Alexander Macomb, appointed June 1, 1821.

Col. and Bvt. Brig. Gen. Charles Gratiot, appointed May 24, 1828.

Brig. Gen. and Bvt. Maj. Gen. Joseph Gilbert Totten, appointed December 7, 1838.

Brig. Gen. and Bvt. Maj. Gen. Richard Delafield, appointed April 22, 1864.

Brig. Gen. and Bvt. Maj. Gen. Andrew Atkinson Humphreys, appointed August 8, 1866.

By the act of March 3, 1863, the Corps of Topographical Engineers of the Army was merged into the Corps of Engineers. The Corps of Topographical Engineers was created by act of July 5, 1838, its two chiefs being, in succession, Col. John James Abert, appointed July 7, 1838, and Col. Stephen H. Long, appointed September 9, 1861.

Topographical engineers were authorized and appointed in the army by the act of March 3, 1813.

Geographers to the United States of America were provided for the Revolutionary Army by the resolutions of Congress, July 25, 1777, and July 11, 1781, Robert Erskine, F. R. S., being the first Geographer appointed.

The Corps of Engineers as now constituted has all the duties formerly imposed upon the Corps of Topographical Engineers, and is charged with all duties relating to the selection, purchase, and survey of the sites, and the plan, construction, and repair of all fortifications, whether permanent or temporary, and their care when not garrisoned; with all channel and river obstructions, including torpedoes required for coast defense; with all works for the attack and defense of places; with all fixed and movable bridges for the passage of rivers; with all lines, redoubts, intrenched camps, bridge-heads, &c., required for the movements and operations of armies in the field, and with making such reconnaissances and surveys as may be required for these objects.

It is also charged with the survey, plan, and construction of harbor and river improvements; with military and geographical explorations, reconnaissances, and surveys, including the geodetic survey of the lakes; and with all engineer duties confided to other Departments than that of War, which may be specially assigned to the corps by acts of Congress or orders of the President of the United States.

CATALOGUE OF ENGINEER SECTION.

CLASS A.

MAPS, DRAWINGS, AND PHOTOGRAPHS.

This class comprises all works and appliances which are represented by drawings alone. In case a model accompanies the drawings the description of the work will be found with that of the model.

No. 1. Map made in the office of the Chief of Engineers, and showing the character and extent of the engineering works. Explorations and surveys of the War Department and of its officers under other Departments of the Government of the United States, from 1776 to 1876. Contributed by Brig. Gen. A. A. Humphreys, Chief of Engineers.

This large map is displayed, by permission of the "American Society of Civil Engineers," in the Main Building, from the west gallery.

No. 2. Graphic representation of the submarine drilling and blasting operations on Coenties Reef, East River, New York, up to August, 1875. Contributed by Lieut. Col. John Newton, Corps of Engineers, brevet major-general, U. S. A., under whose direction the work was done.

The following principal data appear on the map:

Total number of holes drilled	693
Total number of feet drilled	5,467.33
Total number of drill-hole blasts	97
Total number of surface blasts	57
Total number pounds of nitro-glycerine for drill-hole blasts	33,418.75
Total number pounds of nitro-glycerine for surface blasts	2,262.05
Total number pounds of dynamite	74.05
Cubic yards of rock removed	5,553.03
Average depth of holes	8.32
Expenditure of steel for each foot drilled ..... oz.	5.12

Average of one hole drilled to each sharpening.

No. 3. Graphic representation of the submarine drilling operations on Way's Reef, East River, New York. Contributed by General Newton, under whose direction the work was done.

Work was carried on from August 4, 1874, to January 20, 1875, when a depth of 26 feet at mean low water was reached. The original maximum depth was 17.4 feet. This work was accomplished by means of the United States steam drilling scow (see Class D, No. 2). A detailed account of the entire work may be found in the report of the Chief of Engineers, 1875, Part II, whence the following data are taken:

Total number of holes drilled, 292; total number of feet drilled, 2,130.4; total amount of explosives used was: For 65 drill-hole blasts, 15,308 pounds 12 ounces of

nitro-glycerine; for 16 surface blasts, 1,484 pounds nitro-glycerine and 38 pounds 8 ounces of dynamite; rock removed, 3,029 cubic yards.

This was principally accomplished by dredging, a small amount of the *débris* last remaining being raked off into deeper water.

Average cost of hole drilled, including placing of scow, lowering dome, expenses of drilling, cost of sharpening drills, expenditure of steel, hoisting up dome and heaving off scow, $2.05 per linear foot.

No. 4. Map of the flood-plain of the Minnesota and Mississippi Rivers as far south as Arkansas. Contributed by Maj. G. K. Warren, Corps of Engineers, brevet major-general, U. S. A.

The following description by General Warren fully explains the points of interest which have arisen in connection with the surveys represented in this map:

"This map is simply what the title indicates, a map showing the lands overflowed by these rivers in their highest flood stages, sometimes called *alluvial lands* and *bottom lands*, here called *flood-plain*.

"In connection with it, is shown a copy of the alluvial lands from the junction of the Ohio River to the Gulf of Mexico, taken from the Physics and Hydraulics of the Mississippi River by Humphreys and Abbot. Also, a small map showing the former connection of the waters of the Winnipeg Basin in British America with the present Mississippi Basin.

"The investigations resulting in the production of this map were begun in 1866, under act of Congress, for the purpose of devising plans for improving the navigation of the Minnesota River below the Yellow Medicine River, and of the Mississippi River from the Falls of Saint Anthony to the Rock Island Rapids, and also for the purpose of obtaining information with regard to bridging the Mississippi River in a manner least injurious to its navigation between Saint Paul, Minn., and Saint Louis, Mo.

"These investigations were carried on during 1866–'67–'68–'69, and embraced also examinations or surveys of several main tributaries, such as the Wisconsin River.

"The field was thus extensive in itself, and the practical objects sought were of the highest importance.

"The interests of navigation demanded and received the attention of a careful instrumental survey at all places needing improvement. The bridging questions were liable to arise at any part of the river, and therefore required the whole valley to be presented; but as the time and means did not allow of a survey of the whole, the effort was made to compile a map from partial surveys made by ourselves and from data already existing, notably that of the United States land surveys. A difficulty attending the proper compilation of these land surveys arose from their having been made on the opposite sides of the Mississippi River from different base lines or meridians, without having been connected across the river by triangulations or measurements. Such connections we made, as nearly as practicable, at all points of our surveys, which surveys not only included places of natural difficulties to navigation, but all places where bridges were built or were authorized to be built or believed to be soon necessary to build. Besides these surveys, special connections of the United States land surveys were made at other places, and wherever the margin of the overflowed land was undefined by the United States land plats, surveys were made to define them. This map is therefore a considerable contribution to the geography of the Mississippi Valley, as it for the first time brings together the United States land surveys of the opposite banks throughout, with reliability, besides giving the the results of the new surveys.

"This map has an immediate importance to the subject of bridging the river, in presenting at a glance the few points along the Mississippi where high natural banks, suitable for high bridges, approach close to each other. It is seen from this, that or-

dinary economy compels the building of low bridges with draw openings, in the way which now generally prevails.

"Another very important requirement in the bridge problem is the nature of the river-bed as respects its suitability for pier foundations. Almost everywhere the immediate bed is a shifting sand, with the rock-bed many feet below. To ascertain the depth to this rock exactly would require a very large number of expensive borings, which expense would be unwarrantable except where the approximate location of a bridge was already fixed by the business which demanded its erection.

"One of the first and most important observations made in the progress of the investigations was, that generally, where the high banks wore close together, the rock-bed was near the water surface, and that a wide and more ancient valley, with the rock at considerable depths beneath the sand or alluvium, existed alongside of the narrow one. Such places as the Rock Island Rapids, the Des Moines Rapids, and the Grand Chain are instances of this kind.

"Again, lakes like Lake Pepin and Lake Saint Croix are evidences of the recent silting up of the main valley, at points just below them, to a depth of many feet. These together seem to indicate that formerly along the main valley was a river of larger size than at present that had worn away the rock to a great depth, but since filled up by river deposit, and that where the present Mississippi occupies the ancient valley the depth to the bed-rock must always be great. Borings wherever made in the ancient valley confirmed this inference, and showed that the depth to the bed-rock in this valley had no relation to the present river. Practical engineers have now generally abandoned the attempt to reach the bed-rock for pier foundations, but rest them upon piles driven into the sand and protected from being undermined by the current by loose stone thrown around them.

"A study of the nature of the valley of the Mississippi in the interest of the practical questions involved unavoidably drew on a consideration of the causes formerly at work and the changes going on, and this carried the investigation into the region of surface or present geology. In making this latter, a highly probable showing has been made that the Minnesota and Mississippi were formerly much larger streams, receiving the waters of the Lake Winnipeg Basin.

"As it did not appear probable that such a great change of drainage could stand alone, examination was made of other streams. A similar change appears to have taken place with the drainage of Lake Winnebago, in the State of Wisconsin, of Lake Michigan formerly down the Illinois River, and of the Saint Mary's and Saint Joseph's Rivers formerly down the Wabash, now to Lake Erie. Several other similar changes were pointed out as probable. These features were stated at the annual meeting of the Academy of Natural Science at Chicago, Ill., in 1868, and published in the Annual Report of the Chief of Engineers for 1868.

"At that time, too, the hypothesis was advanced that this change of drainage was due to a secular change in the continental slopes, and confirmations of it were cited. The whole subject is further presented in an essay on the Minnesota River, &c., published in 1875, as Ex. Doc. No. 76, 43d Congress, 2d session; also reprinted in the Annual Report of the Chief of Engineers for 1875.

"It is purposed to make very soon a full report on this subject, with copies of the original maps and diagrams. The present map is but an index map to the more detailed sheets, on a scale of two inches to a mile, which latter are in turn index sheets to the detailed surveys, on scales of 200 and 400 feet to an inch."

Nos. 5, 6, and 7. Plan, longitudinal section, and cross sections of an iron shipping and landing pier being erected in the Delaware Breakwater Harbor, under the direction of Lieut. Col. J. D. Kurtz, brevet colonel, U. S. A. Drawings contributed by Colonel Kurtz, and exhibited in connection with a model of the pier. (See class D, No. 9.)

No. 8. Survey of the Delaware Breakwater Harbor, made in 1871–'73, by direction of Colonel Kurtz. Contributed by Colonel Kurtz.

General plan, showing the hydrography of the harbor and the topography of the adjacent shore, with the protective works (breakwater and ice-breaker), and the location of the United States shipping and landing pier. This harbor is situated at the mouth of Delaware Bay, on the Delaware side, just inside of Cape Henlopen. It is sheltered from northwest to east winds by the artificial works, and from other quarters by the land. The works were commenced in 1830 and finished in 1869.

They contain nearly 900,000 tons of granite stone, costing $2,125,000. The stones below low water range from ¼ to 2¼ tons, and are deposited at random. The upper stones are from 2¼ to 5 tons' weight, and are laid with some regularity on the top surface and inner slope. The top surface of the breakwater is 14 feet above mean low water, with an average width of 22 feet. The slope of the sea face is 1 on 3, and the harbor face 1 on 1.

The two works are 1,350 feet apart, and are placed at an angle of 148° to each other. The breakwater is 2,560 feet long on top, and its axis projected intersects the ice-breaker about midway of its length.

The latter work is 1,345 feet long, its top is about 12 feet above mean low water, and its construction is similar to the main work. The upper half of the harbor affords not more than 3 fathoms of water at low water, the lower half gives about 22 feet. The mean tide is 4 feet 6 inches. An average of about 15,000 vessels are recorded as having taken refuge in the harbor each year since 1868.

It having long been evident that the increased use of the harbor made an enlargement of its protected area advisable, a board of engineers was convened in October, 1871, to consider and report upon different plans proposed for this enlargement. The board decided in favor of closing the gap between the breakwater and ice-breaker with stone, at an estimated cost of $1,314,200. No appropriation for this work has since been made.

No. 9. Plans and sections of breakwater; and No. 10, plans and sections of ice-breaker, of Delaware Breakwater harbor. Contributed by Colonel Kurtz.

These drawings were prepared from surveys of the completed work, commenced under Lieut. Col. C. S. Stewart, Corps of Engineers, who was in charge of the work at the time of its completion, and finished under Colonel Kurtz. They give horizontal sections at top at plane of low water and at bottom with cross-sections at intervals of 100 feet.

No. 11. Chart of Crow Shoal and locality inside of Cape May, at the mouth of Delaware Bay. Surveyed with a view to the formation of an artificial harbor on the New Jersey side. Contributed by Colonel Kurtz.

No. 12. Improvement of Philadelphia Harbor. Chart of the Schuylkill River from Chestnut street bridge to its mouth, showing the improvements in progress by the United States. Contributed by Colonel Kurtz.

This work was commenced in 1870, when there were 15 feet at low water at the mouth of the river, and 13 feet at Gibson's Point. From the mouth to the latter locality there is now a channel 20 feet deep, with a width of about 150 feet. Above Gibson's there is a channel about 75 feet wide, with 16 to 18 feet depth at low tide.

About 366,000 cubic yards of sand and mud and 900 cubic yards of rock have been

removed from the river channel. It is proposed to increase the width at the mouth to 300 feet, and the depth to 24 feet, and above Gibson's the width is 150 feet with a depth of 18 feet.

No. 13. Foundations of Fort Delaware. Contributed by Colonel Kurtz.

The piles composing the foundation of this fort on the Pea Patch Island were driven in 1848. A number of these were driven still deeper by means of "followers" during the next year. The whole was then tested with a ringing pile engine, and those which did not stand the required test (about 1,700 in number) were again spliced and redriven. A large part of these were redriven or "punched" by an arrangement devised by Maj. John Sanders, Corps of Engineers, then in charge of the work, in which the hammer gave a short, quick, and uniform blow, so that the piles were easily driven home without breaking the pile-heads or requiring bands as protection; about one-tenth of the whole number of piles were spliced with extra lengths of 10 or 15 feet. The piles were of Chesapeake yellow pine varying in size from 13 by 14 to 12 inches diameter at the butt, and from 12 by 12 to 7 inches diameter at the point; the point scarps were 6 feet long. The piles were 45 feet long before pointing.

The grillage timbers were of white pine 12 inches square; these were worked down to something less than 12 inches in fitting them to the pile-heads.

The piles were placed generally at distances from center to center varying from 2 feet 9 inches to 3 feet 6 inches.

Each pile under the scarp supports 14 tons' weight, equal to 32,000 pounds maximum. Each pile under the piers supports about 13 tons' weight, or 30,000 pounds maximum. Total horizontal area of scarp on ground level, 7,700 square feet. Total horizontal area of piers on ground level, 5,300 feet. Total horizontal grillage area of scarp, 20,000 square feet. Total horizontal grillage area of piers, 27,000 square feet. Total weight of work and armament, 75,000 tons. Total number of piles under the structure, 6,006. Total area of work, 2¾ acres.

Borings made in 1834 gave the stratification of site as follows: From low-water mark, 42 feet of mud mixed with sand. Below this, 20 feet of coarse gray sand, followed by a layer of shells with a little sand. The shells decrease and disappear at 80 feet, the coarse sand continuing to 92 feet where clay is obtained.

No. 14. View of monolithic concrete as constructed on piles at Fort Pulaski, Ga., under the supervision of Lieut. Col. Q. A. Gillmore, Corps of Engineers, brevet major-general U. S. A. Contributed by General Gillmore.

This drawing represents the monolithic concrete structures of the demilune of Fort Pulaski as actually built, resting throughout on piles and grillage, with the non-bearing mud removed. The supporting stratum is sand and oyster shells, into which the piles have been driven from 8 to 10 feet. The thickness of mud between the surface of the bearing stratum and mean low water varies from 0 to 16 feet. The top of the grillage is generally placed 5 feet above mean low water, the rise of the tide at Fort Pulaski being 7 feet. The mud stratum of Cockspur Island is constantly impregnated with moisture to the level of high water. The piles and grillage are of yellow pine. The concrete is made of hydraulic cement, sand, and oyster shells.

The structures shown comprise a portion of the scarp-wall of both faces of the demilune, the foundations of gun platforms, and the breast-height walls for six guns, three service magazines, and one principal or storage magazine (in the center), with connecting bomb-proof passages, and a retaining-wall on the south face.

The scarp-wall was built about forty years ago, and consists of a brick facing and concrete backing. All the other structures were commenced in 1872, and finished in 1875, and are entirely of concrete, except some copings, lintels, sills, and steps, for door-ways and entrances, which are of granite.

No. 15. Drawings of a mortar-mill and concrete-mixer, used upon the public works of the United States. Contributed by General Gillmore.

The details of the concrete-mixer are taken from the one employed at Fort Scammel, Portland, Me.

The mortar-mill consists of a cylindrical tube or barrel 10 feet 3 inches long and 19 inches diameter, the axis of which is inclined at an angle of about 25°. The barrel is supported at the ends upon a frame-work of timber, which is in turn mounted upon a two-wheel carriage, the axle of which also supports the barrel near the middle. One end of the frame rests upon the ground, thus giving the required inclination. Within the barrel is a rotating shaft, bearing a helical blade 6 inches in breadth, having about thirteen turns in the length of the barrel. The outer edge of the blade works close to the inner surface of the barrel, the inner edge being thrown out from the shaft about 1½ inches.

Portions of the top of the barrel are cut away, leaving apertures about 8 inches wide, sections being left at intervals to avoid weakening the barrel. At the lower end of the barrel a hopper is arranged, through which the mill is fed.

To the lower end of the frame before described another frame is firmly attached and rests horizontally on the ground. This frame carries a large pulley, to which the power is applied, this pulley being connected by a beveled pinion and wheel, with the rotating shaft.

The method of charging the mill is given in the following description of the Concrete Mixer (Fig. 1, 2, and 3), which is taken from General Gillmore's work on "Limes, Hydraulic Cements, and Mortars," 4th edition:

"*Mill-made concrete.*—The mill used for making concrete is a cubical wooden box measuring 4 feet on each edge in the inside. It is provided on one face with a trap-door about 2 feet square, and is mounted on an iron axle passing through opposite diagonal corners. An Archimedean screw mortar mill for mixing the concrete mortar s used in connection with the box, and both are driven by a small engine of about 6-horse power.

"Eight revolutions of the box, made in less than one minute, are found to be quite sufficient to produce the most thorough incorporation of the mortar with the broken stone and gravel. Every piece of stone and every pebble and gravel becomes completely coated with mortar.

"In making the mortar the cement, lime, and sand are first rudely mixed together with shovels on the mortar bed, and are then passed through the mill once; one measure of the dry mixture (about a cubic foot) alternating with one small measure of water. The precise amount of water necessary is determined by trial, and will vary from time to time with the more or less moist condition of the sand.

"Four men with barrows are employed in conveying the concrete materials (the mortar, broken stone, and gravel) into the concrete box, one barrowful of mortar (2 cubic feet) alternating with three heaped-up barrowfuls of the coarse ingredients (7 cubic feet). The materials are dumped into the box from a staging erected on the level of the trap-door when at its highest point.

"One charge of the box contains:

"4 barrows of mortar (8 cubic feet).

"6 heaped-up barrows of broken stone (14 cubic feet).

"6 heaped-up barrows of gravel (14 cubic feet).

"After mixing, the trap-door is opened and the contents deposited on the platform below by two or three revolutions of the box. The concrete box produces such a thorough and complete trituration of its contents, that it is not necessary that the mortar should be mixed beforehand. The mortar mill, as an auxiliary, may therefore be dispensed with.

"The ingredients of the mortar (the cement, lime, sand, and water), after being prop-

erly proportioned by measure, and rudely mixed together with shovels, require no further preparation, but may at once be added to the coarse materials in the box.

"The method of charging the box by barrows, practiced at the Staten Island works, is not considered the most economical that can be devised. A crane or derrick, worked by the same engine that turns the box, and having a sweep of sufficient length to reach the mortar bed and the piles of broken stone and gravel, would doubtless be an improvement. A concrete box employed by General Duane, in Portland Harbor, Me., is operated in this way.

"One box of the capacity above described will mix from 95 to 100 cubic yards of concrete in one day of 10 hours, and will do the work very much better than it can be done by hand, and at a saving of from 15 to 20 per cent. in the cost of labor."

The machine represented on the drawing differs in a few details from the one described. It is also provided with the crane for loading, as suggested by General Gillmore.

No. 16. View of Milwaukee Harbor. Contributed by Maj. D. C. Houston, Corps of Engineers, brevet colonel, U. S. A.

The following description was written by Colonel Houston:

"Designed to illustrate the general method adopted by the Corps of Engineers in improving the mouths of rivers emptying into the great lakes, of which this harbor is one of the best examples. The natural mouth of the Milwaukee River was about three-fourths of a mile south of the present entrance. The latter was formed by making a cut through the narrow sand spit separating the river from the lake, building the two piers shown in the view, and dredging the channel between them. The present harbor entrance is entirely artificial, the old mouth having closed up soon after the new entrance was made.

"Before this work was executed the commerce of Milwaukee was conducted from wharves in the open lake, and vessels had no protection whatever. Now there is a channel 17 feet deep, and vessels can enter the river at all times. The piers are constructed of cribs of timber filled with stone.

"The lakes being fresh water, the timber under water lasts indefinitely; that above water from fifteen to twenty years. The superstructure of the piers, *i. e.*, the part above water (built in 1857), is now being replaced by a wall of heavy stone masonry laid without mortar.. This will produce a permanent structure.

"The effect of such piers projected into the lake is to arrest the drift of sand and shingle along the beach caused by prevailing winds, and to cause an accretion. In the case of Milwaukee this drift is to the south, and hence there is an accretion on the north side of the harbor, and an advance of the shore line into the lake. This results in a gradual shoaling of the lake bed north of the harbor, necessitating a periodical extension of the piers. In Milwaukee Harbor this shoaling is very gradual, the harbor piers having been extended but 620 feet since 1857, or at the rate of about 30 feet per annum. A large part of this extension, however, was rendered necessary to attain an increased depth of water in order to accommodate vessels of greater draught, the piers originally having their heads in but 12 feet of water, but now in 17 feet.

"The entire cost of this work is, in round numbers, $500,000, which would be an annual expenditure of less than $27,000, to provide a secure harbor for the principal wheat mart of the West and a harbor of refuge for vessels in distress."

No. 17 to 20, inclusive. Improvement of Fox and Wisconsin Rivers. Photographic views of stone dam at Appleton, Wis. Contributed by Colonel Houston.

This is one of the works of construction on the above-mentioned improvement, the object of which is to obtain water communication from the Mississippi to the lakes. These rivers take their rise in the central portion of the State of Wisconsin,

the Fox emptying into Green Bay, and the Wisconsin into the Mississippi River. At a point nearly midway between Lake Michigan and the Mississippi, these streams are less than 2 miles apart, separated by a low neck of land which is sometimes overflowed at high water. At this point, called Portage, the rivers are connected by a canal. The improvement consists in making slack-water navigation on the Fox by means of locks and dams, and improving the natural channel of the Wisconsin by contracting it by means of wing dams and jetties.

Nos. 21 and 22. Improvement of Fox and Wisconsin Rivers. Stone lock at Little Chute. Contributed by Colonel Houston.

This shows the character of the locks now being constructed. There are twenty-seven of these locks and sixteen dams in the plan or improvement. The levels are connected by short canals, making a total length of canal from the Wisconsin River to Green Bay, a distance of 160 miles, of only 10 miles. The levels formed by the dams are deepened, where necessary, by dredging.

Nos. 23 to 26, inclusive. Improvement of Fox and Wisconsin Rivers. Wing dams on Wisconsin River. Contributed by Colonel Houston.

These views show the general character of the river and some of the dams. The effect of these is to narrow the water-way, confine the current, and consequently increase the depth. The sand, of which the river bed is composed, is scoured out and deposited between the dams, as shown in the views. New banks are thus formed, the width of the water-way reduced, and an increased depth of channel obtained.—Colonel HOUSTON.

No. 27. View of river scraper used on the Wisconsin River. Contributed by Colonel Houston.

This is used for temporarily deepening the channel to admit the passage of boats. The steamer is run up-stream on the bar, the scraper lowered, and the steamer backed off, dragging the crest of the bar into deep water below. It is a modification of the scraper invented by the late Colonel Long, of the Topographical Engineers. It has not been of much service on the Wisconsin River, but has been successfully used elsewhere.—Colonel HOUSTON.

No. 28. Photographic view of steam dredge owned by the United States, for the improvement of the Fox River. Contributed by Colonel Houston.

This machine is of the class known as dipper or single scoop dredges.

An examination of these rivers with a view to establishing a continuous water communication along them was made in 1866. On the Fox, as the records and maps of the Fox River Improvement Company (whose works already occupied the Upper and Lower Fox) were available, estimates were submitted for enlarging their works to admit of 4-feet draught. On the Wisconsin, the examination discovered the necessity of a detailed survey before attempting to fix upon any plan of improvement.

A survey of the Wisconsin was accordingly made in 1868, under the direction of General Warren. His report upon this survey, in which he discusses the nature and characteristics of these streams, may be found in the Report of the Chief of Engineers for 1868. General Warren submitted three plans of improvement, the last of which he recommended.

This plan consisted in cutting a side canal, crossing the river from time to time to keep on the most advantageous ground, and making use of the river itself at the points of crossing. At these points the river was to be improved, and experimental work was commenced at one of these points in June, 1871. The experiments were so satisfactory that it was deemed practicable to obtain the requisite draught along the entire line by improving the natural channel of the river, which was the first of Gen-

eral Warren's plans, referred to above. Revised estimates embracing the results of the experimental work were made; the work was begun, and has since been carried on.

In October, 1872, the existing works on the Fox River were purchased by the United States, but nothing beyond their mere maintenance was projected, until the results which could be obtained on the Wisconsin were known, since it would be useless to improve either of the rivers beyond the capacity which he obtained in the other. In April, 1873, the work of improvement on the Fox was begun, and has since steadily progressed according to the plan indicated heretofore.

Colonel Houston has been in charge of the work, and descriptions in full detail may be found in his reports. (Reports of Chief of Engineers, 1872-'73-'74, Part I, and 1875, Part I.)

No. 29. Photographs of Red River raft; No. 30. Photographic map of Red River, showing the location and direction of the views in the album (No. 40); and No. 31. Photographic map of Red River raft region and Cypress Bayou, contributed by Capt. C. W. Howell, Corps of Engineers, brevet major, U. S. A.

The navigation of Red River has from its commencement been obstructed by the accumulation of drift-wood in its channel.

Not only has navigation been interfered with, but the river itself has undergone great changes, and large areas of its valley have been laid waste by the overflow of water dammed back by the raft. A scanty navigation has been continuously carried on by making use of the lakes, sloughs, &c., which abound in this region, and also using the channels cut by the obstructed water of the river which forced an outlet at different points.

To improve the navigation of this river in accordance with the demands of commerce has long occupied the attention of those interested. Two general plans have been proposed, and both have at different times been tried, but with indifferent success until the present operations were commenced. The first plan had for its object the removal of the raft, thus opening the natural channel of the river; the other accepted and encouraged the existing obstructions in the river itself, and endeavored to enlarge and improve the side channels above alluded to.

The present work is in accordance with the former of these two methods, and actual work on the raft was commenced December 1, 1872.

At this time the area of the floating timber was about 290 acres, and it consisted of forty-two rafts, with more or less of clear water between them, and extended from Carolina Bluffs, a few miles north of Shreveport, to within a short distance of the Arkansas line. The work was performed by means of saw-boats, axes, crane boats, and explosives. On December 26, 1873, a little more than a year from the commencement, the last raft, No. 42, was pierced. (See for further details the Report of the Chief of Engineers for 1873-'74.)

Much of the success of this undertaking may be attributed to the great energy and ability displayed by the officer under whose personal supervision the work was commenced, but who was not permitted to see its successful termination.

Lieut. E. A. Woodruff, Corps of Engineers, the officer referred to, died of yellow fever at Shreveport while in the active discharge of his duties.

No. 32. Drawings of works in the eleventh light-house district. Contributed by Maj. Godfrey Weitzel, Corps of Engineers, brevet major-general, U. S. A., engineer of the district.

The portfolio contains:

1. Chart of the lights in the eleventh district.
2. Plans, sections, and elevations of the following lights:
   - Saint Clair Flats, fourth order.
   - Spectacle Reef.

Skillagalee, third order.
Détour, Whitefish Point, and Manitou Island, third and a half order.
Marquette.
Copper Harbor range lights, first order.
Michigan City, fifth order.
Grosse Point, second order.
Pier-Head light, fifth order.

3. Drawings of fog signal with 10-inch whistle.

No. 33. Photographs of Louisville and Portland Canal, Louisville, Ky Contributed by Maj. G. Weitzel, Corps of Engineers, brevet major-general, U. S. A.

In 1825 the Kentucky legislature authorized a private corporation to construct a canal around the natural obstruction to navigation known as the Falls of the Ohio River. This canal was completed in 1830, at a cost of $1,019,277.09. It was $1\frac{7}{10}$ miles long, 64 feet wide, with three lift locks, each of which was 200 feet long, 50 feet wide, and had a lift of $8\frac{3}{4}$ feet. Soon after the completion of this work complaints were raised that the tolls levied were a burden on commerce, and public opinion decided that the United States, one of the original stockholders, should own the canal and make it free. Acting upon this the Kentucky legislature in 1842 authorized the president and directors to apply the net income to the liquidation of individual stock, and in 1855 all such stock excepting five shares held by directors having been purchased, the United States in order to take possession had only to promise an enlargement and reduction of tolls. Congress, though appealed to, took no action, and, at the suggestion of the Secretary of the Treasury, the directors prepared plans and obtained authority from the legislature to issue bonds and enlarge the canal. In 1860, Congress having ratified this authority, Mr. T. R. Scowden, a distinguished hydraulic engineer, was employed to make detailed plans and superintend the improvement. In 1866, after expending about $1,800,000, the company was obliged to suspend operations, leaving the work in an unfinished condition. In 1868 Congress commenced a series of appropriations, and the work was placed in charge of the Chief of Engineers, United States Army. On the 26th of February, 1872, the new canal, though still incomplete, was thrown open to navigation, and November, 1873, the new work was virtually completed. The cost of the enlargement of canal and construction of new locks was about $3,250,000, of which the Government paid about $1,450,000. On the 11th of June, 1874, in accordance with an act of Congress, the United States assumed the bonded debt of the company, took possession of the canal, and reduced the tolls to a nominal sum, barely sufficient for management and ordinary repairs. The present canal leaves the Ohio River in front of the city of Louisville, passes in a westerly direction around the falls, and enters the river just above Portland, Ky. Its length is $2\frac{1}{10}$ miles and its general width is $86\frac{1}{2}$ feet. The upper entrance is 400 feet wide and suitable turn-out basins are provided. A dam on the crest of the falls will give, when completed, a minimum depth in the canal of 6 feet. The depth of the water in the canal depends upon the stage of water in the river; the least depth being, as just stated, 6 feet, and the greatest depth known about 42 feet 8 inches.

The great expense of the work is due to the fact that its bed is cut through hard limestone rock, and its sides are protected by stone walls, above which rise earthen parapets to a height of 44 feet above canal bottom and $1\frac{1}{2}$ feet above highest known flood. A set of guard gates at the head provide for shutting off water when necessary. At the lower end are the old locks, still preserved as originally constructed, and the two new locks which form the outlet of a short branch canal. These new locks are the pioneers of their size in the world; they have lifts of 12 and 14 feet; their length between miter-posts is 372 feet; available length, 335 feet, and width, 80 feet. The side walls, breast walls, miter-sills, and the piers of the swing-bridge which spans the locks, are built of freestone from Cannelton, Ind. All the masonry is cut

stone, laid in hydraulic cement in regular 200-foot courses, and has for a foundation the same solid rock that forms the floor of the locks. The guard or flood gates at the head of the locks are 47⅞ feet long, and 46 feet 11 inches high. The upper lift gates are 47⅞ feet long, 24¼ feet high, and built of a combination of oak and pine. The middle and lower lift gates are 47⅞ feet long, 31 feet 2¾ inches, and 27 feet 2 inches high, respectively. They are built entirely of oak except planking, which is of pine. The heavy pressure brought on these gates and their enormous size necessitates great strength. The quoin-posts are 28 by 28 inches, and the miter-posts 24 by 28 inches. Each post is built of five pieces. The gate arms are each formed of three pieces. They are 4½ feet wide at center, 12 inches thick at bottom of gate, 6 inches thick at top, and 22½ inches from center to center. The arms are tenoned into the posts and firmly held by iron straps. The planking is 2½ inches thick and placed vertically. Bolts, straps, tie-rods, and heavy fenders strengthen and protect the gates. A chilled-iron socket in the foot of the quoin-post rests and turns on a pivot bolted to the rock. The pivot of hollow quoin having different centers, the gates slightly leave the quoin when opening. The top of quoin-post is held by an iron collar. A portion of the weight of the gates is carried by a mast and suspension rods, and a portion by a roller under the gate near the miter-post. The weight of each gate in the middle set is about 89 tons. The gates are moved by capstans on the side walls adjacent to them. The capstan communicates motion to two horizontal shafts under the coping, which carry drums on which wind and unwind the chains that move the gates. One chain is attached to nearest gate near the foot of its miter-post; the other is carried across and attached to opposite gate, sufficient slack being allowed. Turning the capstan in one direction opens the gates, and turning in the opposite direction closes them. The miter-sills are built in an arched form and abut in the side walls, each stone being bolted to the rock bed. Oak timbers, also bolted to the rock, are supported by the arched stones, form a cushion against which the gates close. The chambers are filled and emptied through the gates, there being ten openings, each 30 by 36 inches, in each set. These openings are at the bottom of the gates, and are closed by iron wickets turning upon a vertical axis operated from the top of the gate. During high water the lower lock is frequently submerged, and occasionally both locks are entirely under water. At such times the sediment deposited in the canal and locks is so extensive that a steamboat and two dredges are constantly employed removing it. Except during high water, when there are 10 feet or more at the head of the falls, the entire navigation of the Ohio River passes through the canal. During the year 1875, 2,880 boats passed through the locks.—General WEITZEL.

No. 34. Portfolio containing drawings of the Saint Mary's Falls Canal, Michigan, and Harbor of Refuge, Lake Huron. Contributed by General Weitzel.

The Saint Mary's Falls Canal was built to enable vessels to pass around the rapids in the Saint Mary's River connecting Lakes Superior and Huron. The rapids have a fall of 18 feet in a distance of one-half mile. The canal is 15 miles from Lake Superior and 60 miles from Lake Huron by the course of the river.

In 1850 a grant of 750,000 acres of land was made to the State of Michigan, by act of Congress, to defray the cost of building the canal.

A company was organized and entered into contract with the State to build the canal for the land grant. Work was commenced in 1853, and on the 18th day of June, 1855, the canal was opened to navigation. It is supposed that it cost the company about $1,000,000.

As originally built the canal was 5,400 feet in length, had a width of 100 feet at the water-line, with paved slopes of 1½ to 1, and a depth of 12 feet of water at mean stage.

The locks, located near the foot of the canal, were two in number, combined, each

350 feet in length, 70 feet in width, with a lift of 9 feet. A guard gate was located near the upper end of the canal.

At the time it was constructed the canal was considered ample in all its dimensions for the existing or prospective demands of navigation, but owing to the rapid development of the commerce of the lakes and the improvement of the harbors, a class of vessels appeared too large to pass the canal when fully laden, and the number increased to such an extent as to occasion very serious delays at the canal, and the hulls of vessels frequently were injured by contact with the slope walls below the water-line. To ameliorate these evils the improvement of the canal was taken in hand by the United States, and work commenced in 1870.

When completed the improvements will consist of a new lock parallel to and opposite the old locks at a clear distance of 100 feet from them; an enlargement of the old canal so as to uncover the approaches to the new lock, deepening the canal to a depth of 16 feet of water, removing the old slope walls, and substituting for them a timber revetment with a vertical face.

The chamber of the lock will be 515 feet long, 80 feet wide, with a lift of 18 feet, and a depth of 17 feet of water over the sills. To facilitate repairs, a pair of guard gates will be placed above the lock chamber and another pair below it. The estimated cost of the improvement is $1,800,000.

The great cost of both the original work and the improvement is due to the difficult character of the excavation, consisting of sandstone overlaid with a compact bed of gravel and bowlders, to the remoteness of the work from points where supplies can be obtained, and to the severity of the winters, during which season a large part of the work was done.—General WEITZEL.

Drawings of Harbor of Refuge.

Lake Huron, four sheets:

a. Map of the lake.

b. Chart of the harbor.

c. Details of cribs.

d. Details of cribs.

See, for description, Class D, No. 14.

No. 35. Map of the Mississippi River, between the Illinois and Ohio Rivers. In eleven sheets, scale 1 to 30,000. Contributed by Col. J. H. Simpson, Corps of Engineers, brevet brigadier-general, U. S. A.

This map was constructed from surveys made under the direction of Lieut. Col. W. F. Raynolds and Colonel Simpson, 1870-'75. This portfolio also contains drawings illustrating the construction of dams and dikes proposed for the improvement of this river in three sheets.

The portion of the river included in these maps is 230 miles long.

This section is liable to floods rising to a height of 41 feet above low water; the mean annual variation is 23.6 feet. These changes of volume produce notable changes in the bed of the stream. Erosions and accretions are extensive, but the greatest changes are in the position and depth of the channel; changes which take place so rapidly and frequently that it is impractible to execute surveys which would convey any true impression of the hydrographic features of the river as a whole.

The surveys from which these maps have been constructed have been in progress several years, and therefore the hydrographic work is wholly omitted.

The first eleven sheets form a continuous map of the Mississippi between the Illinois and Ohio Rivers on a scale of 1 inch to 2,500 feet.

The use of rafts or "mattresses" in the improvement of the Mississippi was suggested by Capt. Charles J. Allen, Corps of Engineers, to Lieut. Col. William F. Raynolds, Corps of Engineers, then in charge of the improvement of this part of the

river, in a report dated February 7, 1872. Subsequently a model was made under the direction of Col. J. H. Simpson, Corps of Engineers, U. S. A., who had relieved Lieutenant-Colonel Raynolds. The suggestion of Captain Allen was modified somewhat after the publication of General Barnard's "Report on the North Sea Canal of Holland, &c., Washington, 1872," which contains a description of a fascine raft, "zinkstukken." This model is represented in sheet No. 12, bearing date of May, 1873, of which a reduced drawing was published in the report of the Chief of Engineers for 1873. The mode of construction was described in specifications for "brush rafts" to be sunk for foundations contained in instructions to bidders on work for the improvement of the Mississippi River, May 23, 1873, and attached to the contracts for that year, of which they form a part.

These brush rafts or mattresses were intended for use in deep water and rapid current, where piles to hold loose brush in position could not be relied upon. They were not used for the reason that the conditions of the works did not require departure from the cheaper mode of securing foundations with piles and loose brush.

Sheet No. 13 shows details of construction of dikes in the Mississippi between the Illinois and Ohio Rivers. Rows of piles are driven to hold in position loose brush which is thrown in in alternate longitudinal and cross layers and sunk by broken stone. Upon this foundation the dike or dam of broken stone and riprap is constructed. This method, substituting on economical grounds loose brush for the fascines in general use in Europe, had been used on several minor Western rivers. It was employed under Lieutenant-Colonel Raynolds in 1872 on the Mississippi River near Alton, Ill. The dam there constructed served as test work, and this mode of construction proving successful has since been followed in all essential features.

Sheet 14 is a comparative map of the Mississippi River near Horsetail Bar.—Colonel SIMPSON.

No. 36. General profile of the Ohio River, compiled from official surveys under the direction of Maj. William E. Merrill, Corps of Engineers, brevet colonel, U. S. A., with a comparison of average slopes for each section of 20 miles.

1. Horizontal scale, 1 inch to 20 miles. Vertical scale, 1 inch to 20 inches.

2. Horizontal scale, 1 inch to 20 miles. Vertical scale, 1 inch to 3 inches.

The general profile of the Ohio River is the profile at low water; and it will be seen on examination that the surface slopes vary greatly in different parts of the river.—Colonel MERRILL.

No. 37. Lake Survey maps. Contributed by Major Comstock, Corps of Engineers, brevet major-general, U. S. A.

These are duplicates of the Lake Survey charts, which will be found catalogued with "Engineer Publications," Class G.

The following memoranda concerning the Lake Survey charts were arranged by First Lieut. D. W. Lockwood, Corps of Engineers:

"The United States Lake Survey charts comprise those of the Great Lakes, so far as completed, and those of special localities on the lakes where the dangers to navigation are such as to require more care in exhibiting details than the small scale to which the lake charts proper are constructed would permit.

"The lake charts are constructed to a scale of $\frac{1}{400000}$, while the scales of special charts vary, being in some cases as great as $\frac{1}{5000}$.

"The usual plan for survey of a lake is as follows:

"1. The establishment of a primary triangulation, the average probable error of

whose angles shall not exceed four-tenths of a second, the probable error of its bases not exceeding $\frac{1}{300000}$ part of their length.

"2. The determination, from the primary triangulation, of secondary points along the shore line to be surveyed, not more than 10 or 15 miles apart, these distances being much less when a secondary or tertiary triangulation can be carried along the shore.

"3. A detailed topographical and hydrographical survey along the shore, based on these points, extending inland about three-fourths of a mile, and lakewards for half a mile, or to the 4-fathom curve; scale of topographical sheets, $\frac{1}{10000}$ or $\frac{1}{20000}$.

"4. A belt of off-shore hydrography done with a steamer and extending from the 4-fathom curve to 8 or 10 miles from land.

"5. Lines of steamer soundings across the lake.

"6. Precise determinations of latitude, longitude, and azimuth at several primary stations; latitude being determined with a probable error in the final result of about one-tenth of a second, and difference of longitude with Detroit by telegraph.

"7. Reduction of field work and construction of the maps.

"In some cases, on account of special difficulty or cost, the primary triangulation has not been carried along the lake shore. Thus on the American shore of Lake Huron points were determined by a combination of astronomical work and triangulation.

"On the east and part of the west shore of Lake Michigan the positions of points needed for the maps were obtained by carrying lines of azimuths and latitudes southward from known points, the longitudes being computed from these azimuths and latitudes.

"In making the final map, the triangulation points are plotted by their geographical co-ordinates, and the topographical and other details reduced from the shore party and hydrographical sheets.

"The map when finished by the draughtsman is engraved on copper at the Engineer Bureau in Washington, and the charts issued are printed from this plate; in some cases, however, when required immediately for the uses of navigation, the first sheets issued are those produced by the photo-lithographic process, or, as was the case with the chart of the lower part of the Detroit River, the final reduction is made and engraved directly on stone, ready for printing, at the office of the Lake Survey in Detroit.

"The field work for Lakes Superior, Huron, Michigan, Saint Clair, and Ontario, for the rivers Saint Mary, Saint Clair, Detroit, and Saint Lawrence, is now completed Lake Erie remains to be done.

"The final charts for Lakes Superior, Huron, and the northern part of Lake Michigan, have been completed, and are now being issued to vessels.

"The following is a list of charts already published, with their scales and dates of publication:

No.	Name of chart.	Scale.	Year of publication.
1	Lake Erie	1-400,000	1852
2	West end Lake Erie	1-120,000	1852
3	Keilys and Bass Islands, Lake Erie	1-50,000	1852
4	Straits of Mackinac	1-120,000	1856
5	East Neebish Rapids, Saint Mary's River	1-15,000	1854
6	Saginaw River	1-10,000	1867
7	Saint Clair Flats	1-32,000	1857
8	Buffalo Harbor	1-30,000	1857
9	Taw. s Harbor, Lake Huron	1-16,000	1857
10	Beaver Island Group, Lake Michigan	1-120,000	1855
11	Eagle Harbor, Lake Superior	1-5,000	1858
12	Agate Harbor, Lake Superior	1-10,000	1858
13	River S int Mary, No. 1	1-40,000	1858
14	River Saint Mary, No. 2	1-40,000	1858
15	Maumee Bay, Lake Erie	1-30,000	1858
16	Eagle River, Lake Superior	1-10,000	1859
17	Ontonagon Harbor, Lake Superior	1-16,000	1859
18	Saginaw Bay, Lake Huron	1-120,000	1860

No.	Name of chart.	Scale.	Year of publication.
19	Thunder Bay, Lake Huron	1-40,000	1860
20	Marquette Harbor, Lake Superior	1-50,000	1860
21	Presque Isle and Middle Island, Lake Huron	1-40,000	1860
22	Lake Huron	1-400,000	1860
23	South end Lake Huron	1-120,000	1861
24	Grand Island, Lake Superior	1-22,000	1862
25	West end of Lake Superior	1-32,000	1863
26	Grand and Little Traverse Bays, Lake Michigan	1-120,000	1863
27	North end of Green Bay	1-120,000	1864
28	Copper Harbor, Lake Superior	1-10,000	1866
29	L'Anse and Keweenaw Bay, Lake Superior	1-30,000	1866
30	Portage Lake and River, Lake Superior	1-30,000	1865
31	Lake Superior, No. 1	1-400,000	1872
32	Lake Superior, No. 2	1-400,000	1870
33	North end of Lake Michigan	1-400,000	1867
34	Huron Islands, Lake Superior	1-30,000	1869
35	South end of Green Bay	1-120,000	1864
36	Lake Superior, No. 3	1-400,000	1873
37	Saint Clair River	1-40,000	1872
38	Isle Royale, Lake Superior	1-30,000	1872
39	Mouth of Detroit River	1-20,000	1874
40	City of Chicago	1-20,000	1874
41	Lake Saint Clair	1-50,000	1874
42	Saint Lawrence River, No. 1	1-30,000	1874
43	Sandusky Bay, Lake Erie	1-20,000	1874
44	Saint Lawrence River, No. 2	1-30,000	1875
45	Saint Lawrence River, No. 3	1-30,000	1875

No. 38. Photograph views of work in Galveston Harbor, Texas. Contributed by Major Howell. Exhibited in connection with models (see Class D, No. 3).

No. 39. Photographs of lake-survey instruments. Contributed by General Comstock.

No. 40. Maps of Ohio, Monongahela, and Wabash Rivers. Contributed by Colonel Merrill.

The five sheets of the general survey of the Ohio are taken from the office files, and are fair samples of the different sections of the river, showing how it changes in width and character as it approaches the Mississippi.

The local profile of the Ohio from Pittsburgh to Wheeling has been prepared from the special surveys made during the last two years with a view to selecting the sites for movable dams (*barrages mobiles*) on this portion of the river, where the surface slope is greatest and the supply of water the least.

The special surveys at *Horsetail*, *Buffington Island*, *Warsaw*, and *Cumberland Island* are samples of the local maps that are always prepared before any work of improvement is undertaken. At *Horsetail* the work actually performed consisted in removing heavy bowlders from the channel. This was done by horses drawing a pair of large wheels, such as are used for transporting boilers and heavy pieces of machinery. Chains were passed under the stones by men standing in the water. The stones were then lifted by means of screws, and afterwards hauled ashore and deposited on the banks. This work was done in August, 1872, when the depth of water at Horsetail was about 2 feet. Over five hundred rocks were removed, some of which contained over a cubic yard. At *Buffington Island* the riprap dam from the Ohio shore to the island was raised to a height of 8 feet above low water, the old longitudinal dike in the Virginia channel was repaired and raised, the cross-dike was removed, and a straight channel along the dike was dredged through the bar. This work was finished in 1875, and has thus far proved a complete success. The *Warsaw* map shows a dike built at this place in 1871. It has improved the channel so much that boats can always pass Warsaw Bar when they can get over the others above and below it. If necessary, a further improvement can be made by raising and lengthening the dike. The *Cumberland Island* sheet represents the state of affairs in 1871, at which date no work had been done on

the dam since 1853. Since the survey was made the gap in the dam has been closed, and the dam has been extended to the head of Cumberland Island. The work has been successful in making the dam stand the water pressure, but it has been a failure from other causes. The original object of building this dam, which was begun in 1833, was to make a connection between the Ohio and the Cumberland at Smithland, in order to improve the access to the Cumberland, and for the local benefit of Smithland, then an important shipping point. The reason why the project is a practical failure is that the chute or channel at the head of the island is invariably filled with sediment at high water, and it takes some time after the river has got low for the water forced over by the dam to cut a new channel through the deposits left in the chute by the previous high water. The result is that for two or three weeks, more or less, after the low-water season has begun, there is less water at Cumberland Island than anywhere else in that section of the river, and navigation is subject to a serious temporary inconvenience. The dam will probably be removed.

The method of *transporting coal* on the Ohio is shown on a special sheet. A coal boat is a rectangular box with square ends, from 160 to 170 feet long, and 26 feet wide. It has a heavy bottom but light sides, and it is usually broken up when it reaches its destination and has been emptied. A coal barge is rectangular in plan, but has scow bows at each end. The sides are solidly built of 8-inch timbers. Its length is about 130 feet, and its width from 24 to 25 feet. Coal barges when emptied are towed back to the mines and refilled, continuing in use until worn out. Coal boats draw 7½ feet and coal barges 6 feet.

Whenever the river rises sufficiently to permit coal boats or barges to descend, they are made up into fleets, each of which is pushed down-stream by a powerful stern-wheel tow-boat, placed at the rear of the fleet. The average tow from Pittsburgh to Louisville is ten barges—at Louisville tows for the lower market are usually doubled. Large tow-boats have taken from Louisville to New Orleans 560,000 bushels of coal (22,000 tons) in one fleet.

The *Wabash River* maps are samples of the special surveys made on this river with a view to its improvement. At *Grand Chain* a channel 2,300 feet long and 100 feet wide was excavated through the rock bar as indicated on the map. At *Coffee Island* a new channel was excavated behind the island; the material excavated at both places being indurated clay crossed by occasional veins of tough limestone. The navigation on the Wabash is small in amount, and the steamboats themselves are small. Should its navigation increase, the narrow channels now provided can easily be widened. It is a peculiarity of the Wabash that the great majority of its bars consist of rock in place.

The *hydrographs* included in the atlas are samples taken from the office files and need no explanation.—Colonel MERRILL.

Nos. 41 to 74.—Maps, drawings, and photographs from the United States geographical surveys west of the one hundredth meridian. First Lieut. George M. Wheeler, Corps of Engineers, in charge.

This survey was organized in 1871, under the direction of Brig. Gen. A. A. Humphreys, Chief of Engineers, with the approval of the honorable the Secretary of War. The immediate charge of the work was assigned to Lieut. George M. Wheeler, Corps of Engineers, at this date still serving. The yearly operations of the work are carried on in pursuance of acts of Congress and upon projects submitted by the officer in charge and approved by the proper authorities.

The primary object of the survey is the gathering of topographical data for a map of the regions traversed west of the one hundredth meridian of longitude, much of which has heretofore remained a *terra incognita*.

This includes the establishment of primary geographical positions by astronomical and geodetic methods; the determination by trigonometric data of the various mountain systems, valleys and plains, together with hypsometric observations for the determination of altitudes.

Incidental to the main purpose, a study of geological formations, examinations, and collections of living and extinct fauna and flora, investigations of resources (wood, water, grass, agricultural capacity and products), location and extent of precious and economic minerals, climatic influences, selection of routes for military and other purposes, water supply for purposes of irrigation, condition of mining and other interests, &c., have received attention, and have been, or will be, reported upon in the published results. A glance at the progress map will show the location and extent of the regions entered, representing with a close degree of approximation, as already mapped, 295,000 square miles in California, Nevada, Utah, Colorado, Arizona, New Mexico, Nebraska, Wyoming, and Montana. A more detailed description of Lieutenant Wheeler's exhibit as a whole will be found in the Appendix.

No. 41. Progress map.
No. 42. Triangulation map.
No. 43. Wall map.
No. 44. Wall map.
No. 45. Wall maps.
No. 46. Original atlas sheets (Nos. 50, 59, 66, 67, 75, 76, 83, 61 (B), 69 (D), in frames.)
No. 47. Atlas sheets.
Legend sheets.
Basin map.
Sheets of conventional signs—the one now in use.
Atlas (rectangle sheets) Nos. 49, 50, 57, 58, 59, 65, 66, 67, 75, 76, 83, 61 (B), 69 (D), 61 (C); also several sheets produced by crayon process.
No. 48. Atlas geological sheets.
No. 49. Photographic copies of atlas maps on reduced scales.

PHOTOGRAPHS.

Landscape views (in frames).

No. 50. Apache scouts in the White Mountains, Arizona.
No. 51. Apache Lake, White Mountains, Arizona.
No. 52. Black Cañon, Colorado River.
No. 53. Black Cañon, Colorado River.
No. 54. Alpine Lake, in the Sierras, California.
No. 55. Cañon de Chelle, New Mexico. Walls 1,200 feet in height.
No. 56. Section of Zuñi Pueblo, New Mexico.
No. 57. Shoshone Falls, Snake River, Idaho.
No. 58. View in Conejos Valley, Colorado.
No. 59. Lost Lakes "Divide" of Rio Grande and San Juan Rivers, Colorado.
No. 60. Beaver Lake, Conejos Cañon, Colorado.
No. 61. Grand Cañon of the Colorado. View from 3,000 feet above river bed.
No. 62. Mountain Park, Conejos Cañon, Colorado.
No. 63. Headlands of the Colorado, near mouth of Paria Creek.

Water-color drawings.

No. 64. Cooley's Park, near Camp Apache, Arizona Territory.
No. 65. Cachina, or rain-dance, Zuñi Indians, New Mexico.
No. 66. Navajo Indians at home.
No. 67. Cactus (*Cereus giganteus*) grove, Southern Arizona.
No. 68. Water olla (⅛ size), from Zuñi Pueblo, New Mexico.
No. 69. Stone arrow-heads (natural size), from ancient ruins in New Mexico.
No. 70. Album of fifty views, selected from those taken in the years 1871, 1872, 1873, 1874.
No. 71. Album of twenty-five selected views.
No. 72. One hundred and forty-four stereoscopic views in stereoscope.
No. 73. One hundred stereoscopic views in box.
No. 74. Twelve transparencies of landscape subjects.

Nos. 75 to 79, inclusive. Drawings of the United States snag-boat J. N. Macomb, designed by and built under the direction of Maj. Charles R. Suter, Corps of Engineers, U. S. A. Contributor, Major Suter. (See also model, Class I, No. 20.)

This boat was selected as being the type of the latest and most improved style of large snag-boats adopted by the Government in the improvement of our western rivers. She differs from those that preceded her, by being single instead of double hulled, and in being made of iron instead of wood. She is also 20 feet longer. These changes allowed a much stronger and more substantial boat to be constructed on a much less draught of water than the old ones, and facilitated a better and more economical arrangement of the machinery. The boat has been tested by eighteen months' service, and has proved fully satisfactory.

The following dimensions and statistics embrace the main points of interest:

Hull built in Cincinnati in 1873 and 1874.

Machinery built in Saint Louis and Cincinnati.

Total cost of boat, $180,000.

Monthly expense of running, $3,500.

Carries a crew of thirty-eight officers and men.

DIMENSIONS.

	Feet.	In.
Length between perpendiculars	175	
Length over all	177½	
Beam on deck	62	
Beam extreme (over guards)	90	7½
Height of hull over all	8	
Sheer (reversed each way from center)	2	
Length of well on deck from stems	64	11½
Width (least) of well on deck	9	10
Draught, loaded	3	4½
Displacement, in tons of 2,000 pounds	893	

MACHINERY.

Main engines.—Two high-pressure, non-condensing. Cylinders, 26 1/16 inches diameter, stroke 6 feet. Indicated horse-power of engines, 556.27.

These engines drive two water-wheels 24 feet in diameter, at a rate of 18.4 revolutions per minute, giving a speed in still water of 8.37 miles per hour.

Boilers.—Five, cylindrical, externally fired. Diameter of shells, 42 inches. Length of shells, 24 feet 1½ inches.

Flues.—Four in each boiler. Outside diameter, 10 inches. Steam drum (one), and mud drums (two). Pressure of steam carried, 140 pounds, by gauge.

Fuel burned per hour (maximum).—Coal (bituminous), 2,439 pounds.

Boilers and steam pipes covered with "Salamander" asbestos felting.

Pumping-engine.—Steam cylinder, 10 inches diameter, 20 inches stroke. Heaters (two), 6 feet long 34 inches diameter. Water heated by exhaust steam. Hand-pump, steam fire-pump, steam boiler feeder for nigger boiler, and steam siphons in addition to the above.

Hoisting-engines.—Cylinders (two) coupled at right angles. Diameter of cylinders, 10 inches; stroke, 15 inches; capacity of hoisting purchase (estimated dead lift), 75 tons.

Forward capstans.—Four in number, each pair driven by an engine located in the hold. Capstans each take in 38 feet of line per minute, with a pull of 15 tons.

After capstans.—Two in number, each driven by an engine in the hold.

Saw-engines.—Two in number, located in hold. Forward saw: steam cylinder, 6 inches diameter, 30 inches stroke, direct attachment to saw. After saw: steam cylin-

der, 6 inches diameter, 14 inches stroke; works the saw by means of a rocker. Stroke of saw, 40 inches.

Method of operating.—The bow of the boat is forked for a length of 65 feet, and the well thus formed has a width varying from 9 feet 10 inches aft to 35 feet forward. Near the bow the well is spanned at the water's edge by a massive collection of heavy timbers sheathed with iron. These timbers, known as the butting beam, extend in one length from out to out of the boat tying the two forks together and furnishing a broad working platform. Over the beam stands a heavy pair of iron shears, capable of lifting 200 tons, and back of the shear legs come the steam capstans, two on each fork of the hull. At the end of the well, raised on massive iron frames, is the iron hoisting-drum, by which the large hauling or hoisting chain is wound in, and two rollers—the foward one fixed or swinging at will, while the after one travels on rails—span the well and form a cradle or log way to receive the snags when they have been pulled up over the butting beam. One steam-saw works out through a slot in the boat's side in line with the front of the butting beam, the other one, by means of a detachable rocking arm, works above deck in line with the axis of the forward roller. Over the stems, and forming a bight between them, hangs a 1⅝-inch stayed link chain which can be raised or lowered at pleasure, and by means of which snags under the surface of the water are grappled and raised on to the beam.

Snags almost invariably point downstream. They are inclined at various angles, depending upon their length and the depth of water, and their roots are usually imbedded, often very solidly, in the sand or mud of the bottom. The boat, headed upstream, slowly approaches the snag from below, and the end of it, being raised on to the beam, is secured with lines, which are taken to the capstans and wound in, the boat still coming ahead if possible. If the tree be large and heavy the hoisting chain is made fast and hauled in, the capstans being reserved for light lifts and the various maneuvers required to guide the heavy tree trunk, preventing it from rolling about and smashing the upper works, &c. When knots and limbs are met with, they are sawed or broken off, or they are lifted clear of the beam with the shears. As the tree comes in, it is cut off by the saws at every 20 or 30 feet of its length, the pieces being dropped into the well and allowed to float away. Finally the root is reached and is pulled up close to the face of the butting beam, the trunk of the tree resting on the rollers. The root is then sawed off and dropped in some deep hole or out-of-the-way place, and the trunk sawed up into short pieces. If these will not float they are dropped with the stump, otherwise they go into the well and float off. In all these operations, the boat herself assists, being moved and guided by the main engines and water-wheels, which are quite separate and distinct. In case a simple pull is insufficient to dislodge a snag, various expedients are resorted to, especially surging the boat backward and forward, at the same time winding in or out the hoisting-chain. This severe usage proved too heavy for chains made of 2 and 2⅛ inch iron, but the 2¼-inch chain used on the Macomb has not been broken as yet.

In case these comparatively mild expedients fail to dislodge an obstinate customer, chains and lines are cast off, the forecastle deck cleared for action, and the boat, dropping back 300 or 400 yards, runs at the snag as hard as her engines can drive her. The blow is received upon the face of the butting beam, which requires to be exceedingly well fastened, as well as heavily iron-plated, to stand these tremendous shocks. Blow after blow is thus given, from above as well as from below, from the right and from the left, until finally the root is torn out of its muddy bed, and the snag is then pulled aboard and disposed of.

In this violent exercise a heavy boat weighing nearly 900 tons, and moving at a rate of at least 5 miles an hour, is suddenly brought to rest within a space of a few inches, the striking force amounting to 13,000,000 foot-pounds. These tremendous shocks, combined with the great strains produced by the heavy weights which are constantly lifted on and off the head, require, as may be imagined, a very solid construction, and the combination of lightness and strength of hull with powerful machinery

and working appliances has required a great many years of work and many experiments in construction to give us boats even as good as the one here described.

To remove and cut up a large snag from thirty minutes to an hour is usually required, though, in cases of unusual difficulty, several hours or even days are required for the purpose.

The amount of work done depends, of course, largely on the plentifulness with which snags are met with. When they are only found at long intervals, the count is of course much reduced, but taking together the labor of all the boats engaged in this work, the number of snags removed every year amounts to many thousands. Since the Macomb was built she has had 267 working days, and her record for that time is given herewith.—Major SUTER.

Operation of the snag-boat J. N. Macomb.

Name of river.	Number of days in commission.	Number of snags pulled.	Weight, in tons of 2,000 pounds.	Number of trees cut.	Number of drift piles removed.	Number of miles run.
Mississippi	11	13	249.6			4,463½
Missouri	117	992	16,199.7	1,913	30	
Arkansas	139	1,208	19,202.0	2,378	14	
Total	267	2,213	35,651.3	4,291	44	4,463½

Nos. 80, 81, 82. Photographs of snag-boat described above. Contributor, Major Suter.

No. 83. Details of pumping-apparatus, bins for holding sand, &c., of the United States dredging-steamer Henry Burden, employed on the Savannah River improvement, 1874–'75. Designed by Lieut. Col. Q. A. Gillmore, Corps of Engineers, brevet major-general, U. S. A. Contributor, General Gillmore.

The following description of the dredging steamer and apparatus is taken from General Gillmore's report for 1872:

The steamer, originally built for carrying passengers and light freight, is 132 feet long on the keel, 24½ feet broad on the beam, and when ballasted on an even keel draws about 5½ feet of water. She was modeled with a view to speed, and carries only 100 tons on a draught of 7 feet, is strongly built, with side wheels and short guards, has one low pressure engine of 120 horse-power, and ample boiler capacity. Although the most suitable boat for the purpose that could be chartered at the time, she is not exactly adapted to the work required of her, on account of her comparatively deep draught and small carrying capacity, which renders it impossible to prosecute work continuously during the period of low water. A boat with more beam, and a fuller model fore and aft under the water-line, would have been better.

The pump, a No. 9 centrifugal-drainage pump of the Andrews patent, is located on the main deck, aft, about 35 feet from the stern-post. Its main suction and discharge openings are each 9 inches in diameter. To the suction-opening there are connected, by a two-way branch-pipe, two 6-inch suction-pipes, instead of one 9-inch, as usual, the object being, in dredging on the Saint John's bar, not only to work on both sides of the boat simultaneously, but to render the necessary handling of the pipes as easy and prompt as possible. There is, on the other hand, considerable disadvantage in operating with two suction-pipes instead of one, on account of the

greater amount of friction for an equivalent suction capacity, for while a 9-inch pipe has an area of only 81 circular inches, two 6-inch pipes have an aggregate area of only 72 circular inches. The frictional surface is therefore increased as 27 to 36, making the disadvantage from this cause as 2 to 3. The discharge of materials is made through a 9-inch pipe branching in a two-way pipe into two 6-inch discharge-pipes.

It was necessary also to encounter another disadvantage by using severals bends, of which there were two in each of the suction-pipes, one in the main discharge-pipe, one in one of the 6-inch branch discharge-pipes, and two in the other, those in the suction being each one-eighth of a circle and those in the discharge one-fourth of a circle each.

These bends reduced the delivery at the rate of 10 per cent. for each turn of 90° and about 6 per cent. for each turn of 45°, these reductions being calculated for each case upon the quantity passing the preceding bend. Thus the first one-eighth bend in the suction reduces the quantity to 94 per cent., the second to 88 per cent., and the one-fourth bend in the main discharge to 79 per cent., one-half of which is reduced by one bend in one of the branch discharge-pipes to 36 per cent., and the other half by two bends in its discharge-pipe to 31 per cent., leaving for the net delivery 67 per cent. of the theoretical quantity pumped.

The disadvantages, therefore, under which the apparatus labored, may be briefly summarized as follows:

1st. The loss by friction, due to the use of two 6-inch instead of one 9-inch suction-pipe, is increased 50 per cent.

2d. The loss by friction due to the use of suction-pipes three times as long as the height to which the material is to be raised.

3d. The loss of 33 per cent. in the theoretical quantity pumped up by bends in the suction and discharge pipes.

As the pump will not charge itself, the charge is supplied by a small donkey-pump, through a hole made in the top for that purpose. The charge is retained while turning the boat on the inside of the bar, and during the night, and at other intervals when work is temporarily suspended, by closing the side-valve in each of the suction-pipes, where it passes over the side of the vessel.

The engine used to drive the pump consists of two cylinders connected upon one crank, at right angles to each other, and 10 inches in diameter by 10 inches stroke each. Steam is conveyed from the steamer's boiler to the pump-engine through a 3-inch iron pipe, the usual pressure carried upon the boiler being about 25 pounds to the square inch. This pressure develops about 26 useful horse-power, after deducting 25 per cent. for friction of engine and difference of pressure in the cylinder and boiler, and gives a speed of about 180 revolutions per minute to the engine-shaft. On this shaft is a pulley 42 inches in diameter, carrying a rubber belt 12 inches wide, communicating the power to the pump-shaft through a pulley 24 inches in diameter, thus giving the pump-disk and wings about 315 revolutions per minute. This speed in the No. 9 pump is equal to the work of raising 3,000 gallons of clear water per minute 30 feet high, through a 9-inch straight vertical pipe.

The actual height raised above the surface of the water on the Saint John's bar varies with the amount of sand taken on board, from 10 to 11 feet, but as the pipes are 50 feet long, with bends, and are in two branches instead of one, and as a mixture of sand and water is heavier and more impeded by friction than clear water, the loss by friction, from all these causes combined, reduces the useful work of the pump considerably below the average attainable under more favorable conditions. For these reasons, although 200 revolutions of the pump-disk per minute will easily raise 3,000 gallons of clear water 12 feet high through a vertical 9-inch pipe, 300 revolutions are required to raise 2,500 gallons of sand and water 11 feet high through two inclined suction-pipes, having two turns each, discharged through a pipe having one turn.

To prevent the ends of the suction-pipes being lifted off the bottom by the piloting of the boat, a portion of each pipe is made flexible, being composed of 6-inch rubber

hose stretched over a spiral spring. In addition, the ends are loaded with an iron frame or drag, each weighing about 200 pounds, which is intended to move along flat upon the bottom during the operation of dredging. To the under surface of this frame, directly below the mouth of the pipe, a number of teeth or knives are attached to stir up the sand and aid its entrance into the pipe.

A chain attached to each drag, and leading to the deck of the steamer on either side, takes the strain from the pipe when the drag is down and the steamer in motion. Another chain runs along the pipe, and is attached to all the flanges.

Tackles are arranged for lifting the pipes from the bottom when not dredging, or when pumping clear water, to discharge the sand from the bins.

For receiving the sand, bins are located along the main deck, fore and aft, on each side of the steamer's engine, each being provided with a sliding gate over the steamer's side, which can be opened and closed at pleasure. The bins are filled from two troughs, one from each branch of the discharge-pipe, provided at suitable intervals with valves or gates, so that the load can be distributed to the bins wherever desired.

The proportion of sand that can be pumped depends greatly upon its specific gravity and degree of fineness. The calcareous and argillaceous sands flow more freely than the silicious, and fine sand is less liable to choke the pipe than those that are coarse. When working at high speed, 50 to 55 per cent. of sand can easily be raised through a straight, vertical pipe, giving for every 10 cubic yards of material discharged 5 to 5½ cubic yards of compact sand.

With the appliances used upon the Saint John's bar, and in consequence of the swell, which frequently lifted the ends of the suction-pipes from the bottom, the proportion of sand seldom exceeded 45 per cent., generally ranging from 30 to 35 per cent., when working under the most favorable conditions. In pumping 2,500 gallons, or 12.60 cubic yards, of sand and water per minute, we would therefore get from 3.7 to 4.3 cubic yards of sand. During the early stages of the work, before the teeth under the drags had been properly arranged to aid the flow of sand into the pipes, the yield was considerably below this average, not often greatly exceeding and frequently falling below 2 cubic yards of sand per minute during the time actually occupied in pumping. At a later period much better results were obtained.

The manner of conducting the dredging may be briefly described as follows:

The steamer, with the suction-pipes up, first crosses the bar to the outside, then turns around and steams slowly in over the bar, with just sufficient speed to maintain steerage-way, lowering the pipes and starting the pump as soon as the outer edge of the bar is reached. Arriving on the inside the pump is stopped, the pipes raised, and the steamer turned around again. She then crosses slowly to the outside, pumping as before, and the quantity of sand discharged into the bins, during these two passages over the bar, is a load, whether great or small. While the steamer is turning around on the outside, preparatory to taking in another load, the side-gates to the bins are opened, the suction-pipes are raised from the bottom, and the pump is run at full speed on clear water. By this means, assisted to some extent, where necessary, by men in the bins, with hoes, the sand is all discharged into deep water by the time the steamer again reaches the outer edge of the bar, when the dredging is resumed.

The time required to turn the steamer twice is twelve to thirteen minutes, of which only six to six and a half minutes, or the time occupied in making the turn on the inside, is lost, as neither the work of dredging the sand nor discharging it from the bins is in progress during that interval.

No. 84. Chart of Matagorda Bay. Contributed by Capt. C. W. Howell, Corps of Engineers, brevet major, U. S. A.

CLASS B.

ASTRONOMICAL, GEODETIC, AND METEOROLOGICAL INSTRUMENTS.

(Exhibited to show the range and quality of instrumental work performed by Engineer officers.)

These instruments are collected from the office of the Lake Survey, from the office of the Geographical Survey west of the One hundredth Meridian, and from the School of Submarine Mining and Military Engineering at Willets Point, New York.

A.—ASTRONOMICAL INSTRUMENTS.

No. 1. Astronomical transit with broken telescope. Contributed by Major Comstock, Corps of Engineers, brevet major-general, U. S. A. Pistor & Martins, Berlin.

Focal length, 24 inches; diameter of object glass, 2½ inches; the horizontal limit reads to 10″; the finding circles to 1′; can be used as a transit or zenith telescope.

No. 2. Combined transit. Contributed by Lieutenant Wheeler, Corps of Engineers. Made by Wurdeman, Washington.

Focal length, 32¼ inches; clear aperture, 2 1/16 inches; two finding circles, 4 inches diameter; one setting circle, 5 inches diameter; one V has a horizontal and the other a vertical micrometer motion.

No. 3. Combined transit. Contributed by Major Abbot, Corps of Engineers, brevet major-general, U. S. A. Made by Wurdeman. Same as No. 2, except the following dimensions:

Focal length, 30¼ inches; clear aperture, 2½ inches; setting circle, 6½ inches; finding circles, 4 inches.

No. 4. Astronomical transit. Contributed by Major Abbot, Corps of Engineers, brevet major-general, U. S. A. Stackpole & Bro., New York.

Focal length, 24½ inches; one finding circle, 6 inches diameter; direct and diagonal eye-piece.

No. 5. Portable astronomical telescope. Contributed by Major Abbot, Corps of Engineers, brevet major-general, U. S. A.

Focal length, about 33 inches; aperture, 3 3/16 inches.
Motions in altitude and azimuth by endless screws, attached to long handles.

No. 6. Sextant, No. 1668, Stackpole & Bro., New York. Contributed by Major Abbot, Corps of Engineers, brevet major-general, U. S. A.

Vernier reacts to 10″.

No. 7. Reflecting circle. Contributed by Major Abbot, Corps of Engineers, brevet major-general, U. S. A. Gambey, Paris.

Limb and vernier read to 20′ and 20″, respectively.

No. 8. Electro-magnetic chronograph. Contributed by Major Comstock, Corps of Engineers, brevet major-general, U. S. A. Bond & Son, London.

The motive power employed is electro-magnetism. The rate of motion is regulated by the conical pendulum, which either makes and breaks the current or does not make it according to its spur. The arrangement of the different parts is as follows: To the base board is attached an electro-magnet (horseshoe), which is stationary; above it is its armature, which consists of two cross-bars at right angles, and is fastened to a vertical revolving shaft, which at its upper extremity has projecting from it nearly at a right angle a slotted arm, which engages the spindle projecting from the ball of the pendulum near its upper extremity; the armature shaft is supported by a collar, in which it turns, but from which it is perfectly insulated; from this collar project horizontally four stationary arms, one of which is connected with one extremity of the coil about the magnet; the other extremity of the wire leads to the battery; the pendulum is connected through its supports with the other pole of the battery. From the spindle below the pendulum ball projects a small spiral spring, which, by coming in contact with the stationary arms, makes the circuit. The arrangement of the pendulum and armature is such that when the spiral spring makes the circuit the ends of the armature will be near to and approaching the ends of the magnet. When the current is made the magnet attracts the armature shaft and carries the pendulum spring by the stationary arm and breaks the circuit; the pendulum under the impetus it has received moves on making the circuit on the next arm, &c.

Should the motion become too rapid, the pendulum is carried so far out from its axis of rotation that the spring does not work the arm, no current is made, and the motion is checked.

When the chronometer is connected with the chronograph, the connection is so made, by means of a double relay, that the breaking of the chronometer every second will close the driving circuit at a time when one of the arms of the armature is approaching the poles of the magnet; but in advance of the closing of the circuit by the ordinary circuit-closer is the spiral spring and stationary arm, so that if the rate of motion is too slow, it will be accelerated and kept uniform.

No. 9. Personal equation instrument. Contributed by Lieutenant Wheeler, Corps of Engineers, consisting of: 1, artificial transit apparatus; 2, chronograph, break-circuit chronometer, key-board, &c.

The automatic transit apparatus is the design of Dr. F. Kampf, astronomical assistant to Lieutenant Wheeler.

No. 10. Geodetic instruments. Theodolite No. 2, Troughton & Sims, London. Contributed by General Comstock.

Repeating instrument. Horizontal limb, 12 inches diameter; vertical limb, 12 inches diameter; horizontal limb is graduated to 5′ and read to 1″ by 2 reading. Vertical limb graduated to 5′ and read to 5″ by verniers.

No. 11. Theodolite No. 66. Contributed by Major Abbot, Corps of Engineers, brevet major-general, U. S. A. Wurdeman.

Repeating instrument. Focal length, 14½ inches; diameter of horizontal limb, 10 inches; no vertical limb. Horizontal limb graduated to 5′, read by verniers to 5″; illuminating axis.

No. 12. Theodolite No. 1324, Pistor & Martins, Berlin. Contributed by Major Comstock, Corps of Engineers, brevet major-general, U. S. A.

Non-repeating. The telescope is mounted outside the Ys, and has a focal length of 9½ inches. Diameter of horizontal and vertical limbs, 5½ inches. Both limbs are graduated to 10′ and read directly to 10″ by reading microscopes, and by estimation to 2″. The instrument has a vertical setting circle graduated to 5°.

No. 13. Surveyor's or railroad transit No. 1585, Stackpole & Bro., New York. Contributed by Major Abbot, Corps of Engineers, brevet major-general, U. S. A.

No. 14. Topographical or "meandering" transit No. 4950, Young & Sons, Philadelphia. Contributed by Lieutenant Wheeler, Corps of Engineers.

Three and one-half inch limb; reads to 1'. Has a light tripod, and is carried from point to point by a man on horseback with the feet of the tripod resting in a lance socket.

No. 14 (*a*). Triangulation and azimuth instrument. Contributor, Lieutenant Wheeler.

No. 15. Level No. 1628, Stackpole & Brother, New York, and target. Contributed by Major Abbot, Corps of Engineers, brevet major-general, U. S. A.

No. 16. Gradienter No. 9. Contributed by Major Abbot, Corps of Engineers, brevet major-general, U. S. A.

Vertical limb; reads to 1 minute. Tangent screw has a micrometer head, by which a closer reading may be taken.

No. 17. Surveyor's compass.

No. 18. Binocular field-glass.

No. 19. Large spy-glass.

No. 20. Small spy-glass.

No. 21. Surveyor's chain.

No. 22. Pocket-sextant.

No. 23. Hand-level.

No. 24. Surveyor's level.

No. 25. Prismatic compass.

No. 26. Protractor, Abbot's.

No. 27. Tape, measuring.

Nos. 17 to 27, inclusive, contributed by General Abbot.

METEOROLOGICAL INSTRUMENTS.

No. 28. Theodolite magnetometer for determining the intensity and direction of magnetic currents. Contributed by General Abbot.

The needle of this instrument is a small telescopic tube of steel, magnetized, and its direction is ascertained by bringing its line of collimation in coincidence with that of the theodolite telescope by moving the latter, and then reading the horizontal limb. For a full description of the instrument and its use, see papers of the Essayons Club, Corps of Engineers, No. —, by Capt. C. W. Raymond.

No. 29. Dip circle, large. Contributed by Lieutenant Wheeler, Corps of Engineers.

No. 30. Dip circle, small.

No. 31. Mountain barometer cistern, with stand.

No. 32. Hygrometers, set. Contributed by Lieutenant Wheeler.

No. 33. Maximum and minimum thermometer. Contributed by Lieutenant Wheeler.

No. 34. Aneroid barometer, with scale of altitudes. Contributed by Lieutenant Wheeler.

No. 35. Aneroid barometer. Contributed by Major Abbot, Corps of Engineers, brevet major-general, U. S. A.

No. 36. Cistern barometer. Contributed by General Abbot.

No. 37. Deep-sea thermometer. Contributed by Major Comstock, Corps of Engineers, brevet major-general, U. S. A.

Maximum and minimum. This instrument, for measuring past extremes of heat and cold and present temperatures, consists of a glass tube bent in the form of a siphon, the ends terminating in bulbs, one of which is considerably lower and much larger than the other. The lower part of the siphon is filled with mercury, while the remainder of the tube—the larger bulb and about one-third of the small bulb—are filled with rectified alcohol. The remaining space in the small bulb is filled with highly compressed air, which acts as a spring to force the mercury down the branch connected with the small bulb and up the other when the volume of the alcohol is diminished by a lowering of the temperature. A steel index inclosed in glass moves in each limb of the siphon. The two indices are terminated at top and bottom with glass ends to enable them to move with the least friction possible and to prevent the mercury from passing them. The indices are adjusted by means of a small magnet. While in use for sounding, the thermometer is inclosed in a copper case, perforated at top and bottom, for protection.

No. 38. Model of triangulation station as used in the Lake Survey. Contributor, General Abbot.

This consists of a tall tripod, surrounded by a four-sided pyramid, both of poles roughly fastened together. They are entirely separate, the inner one supporting the instrument in use, and the outer the weight of the observers, the force of wind, &c.

No. 39. Odometer. Contributed by General Abbot.

No. 40. Pocket thermometer. Contributor, Lieutenant Wheeler.

No. 41. Implement box (meteorological). Contributed by Lieutenant Wheeler.

CLASS C.

TORPEDOES, BATTERIES, ELECTRICAL INSTRUMENTS.

All the contributions to this class are by Maj. H. L. Abbot, Corps of Engineers, brevet major-general, U. S. A.

The torpedo system here partly exhibited is that devised by General Abbot, and adopted by the War Department for sea-coast defense.

It is operated by electricity either on open or closed circuit, as desired.

The mines, in groups of three, may be exploded, or be rendered automatically destructive or inert at pleasure.

They are flanked by the guns of the fort from which they are served, and any disturbance of the torpedoes or cutting of the cables draws an automatic fire from the guns.

An injury to the system at once becomes known by simple electrical tests, which also indicate its nature and locus.

The United States Engineer troops are trained to practically apply this torpedo system to the defense of harbors and rivers; the school of application being at Willets Point, New York Harbor.

No. 1. Tank containing models of torpedoes afloat, showing the relations of the different parts to each other. Want of space contracts unduly the horizontal dimensions of this relation. Models were made by Sergeant Nolty, Engineer Battalion.

No. 2. Tank containing models of an iron crate (50 by 10 by 10 feet), and a ring, which have been successfully used at the school of submarine mining at Willets Point, New York, in experiments made to determine the nature, amount, and laws of transmission of forces developed by the explosion of submarine mines.

The construction of the crate merits attention, being so contrived that the planes of its different parts all pass through the center of the charge, thus presenting a simple knife-edge to the force of the explosion. Gauges placed at the different corners register the pressures at the instant of explosion.

The crate was handled by two derricks placed upon a schooner, and was supported at the desired depth by buoys, or, in some cases, was allowed to rest upon the bottom.

The effects of numerous charges, varying from 5 to 100 pounds of dynamite No. 1, were successfully measured by this crate. The final charge left it in the condition shown in an accompanying photograph.

No. 3. Box containing signal battery—Leclanché for open, and bichromate of potash for closed, circuits.

No. 4. Box containing 10 Leclanché cells, of pattern adopted for firing battery.

No. 5. Leclanché testing battery—compact, portable form.

No. 6. Operating box, containing apparatus for controlling and testing the mines (details not exhibited).

No. 7. Box of resistance coils, for use with powerful currents.

No. 8. Alarum, &c. (details not shown).

No. 9. Bradley galvanometer, adopted for rough testing.

No. 10. Siemens universal galvanometer, adopted for fine testing.

No. 11. Bridge rheostat, for measurement of electrical resistances, &c.

No. 12. Reversing key, devised by General Abbot, for measurements which include the earth as part of the circuit.

No. 13. Buoyant torpedo (model 1873), with its anchor.

When the river current is feeble, the insulated cable may take the place of the anchoring chain, as here exhibited. This mine contains the explosive charge, fuzes, and circuit closer or breaker (details not shown) complete.

No. 14. Buoyant torpedo, model 1875, with its anchor.

A mooring of wire rope, as used in strong currents, is here exhibited. Contents of mine like No. 13.

No. 15. Ground torpedo for shallow channels.

Loaded, it weighs 500 pounds, and forms an anchor for the circuit-closer buoy, which rides above it.

No. 16. Mine and detached circuit-closer buoy, as arranged to foil operations by vessels protected by outriggers.

The outrigger passing over the torpedo strikes the detached buoy, and thus explodes the charge under the bottom of the vessel.

No. 17. Grand junction box.

No. 18. Triple junction box.

No. 19. Single junction box.

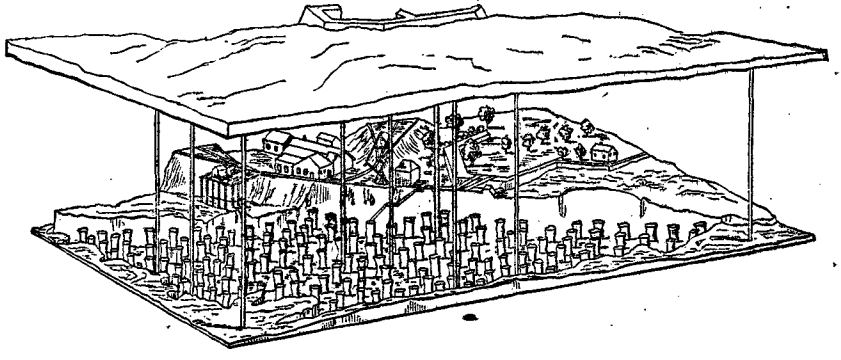
These boxes are for uniting the electric cable in such a manner as to prevent any strain from coming upon the core.

CLASS D.

MODELS OF ENGINEERING WORKS AND APPLIANCES.

No. 1. Topographical model of the rock obstructing the channel of East River at Hallet's Point, Hell Gate, New York. Contributed by Lieutenant-Colonel Newton, Corps of Engineers, brevet major-general, U. S. A.

Showing the system of mining adopted by the United States for its removal by means of a coffer-dam, shaft, headings, and galleries, as executed under the direction of Bvt. Maj. Gen. John Newton, lieutenant-colonel, Corps of Engineers; Captain W. H. Heuer, assistant in charge of execution. Model constructed from official surveys by F. von Egloffstein, civil engineer, New York. Scale 1 to 150.



Model of Hell Gate.

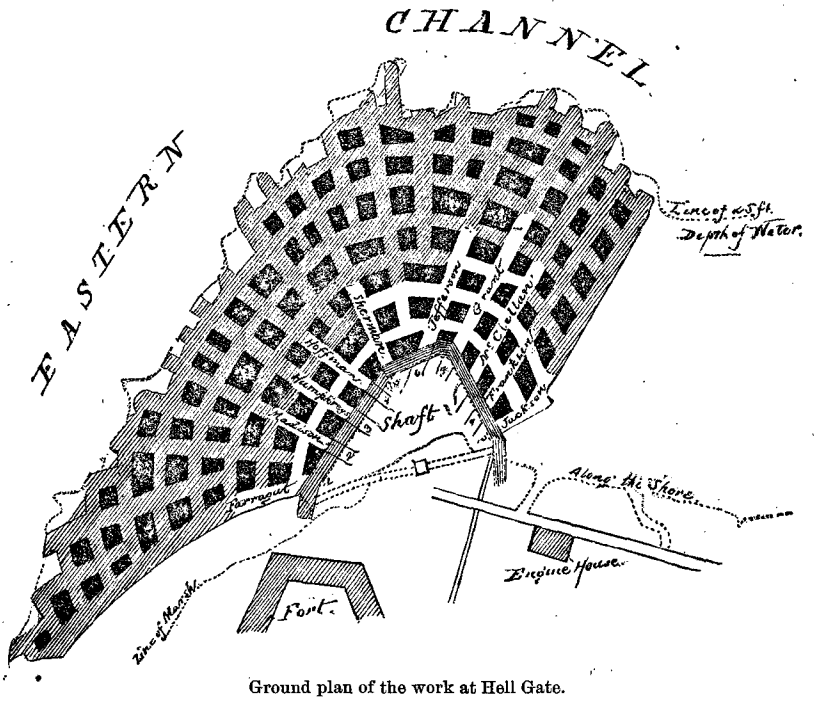
The passage known as Hell Gate is a narrow and tortuous channel in East River, between Long Island and Ward's Island, which latter extends from One hundredth street, New York City, to about One hundred and fifteenth street.

The channel is obstructed by numerous reefs of greater or less extent, and is also rendered much more dangerous by the violence of the abnormal currents or eddies, caused by the high velocity which the water must have at this point to accommodate itself to the rise and fall of the tide in the broader bay below. Hallet's Point, the location of this work, is a salient, on the Long Island side, forming the sharpest bend in the channel, and is the cause of the most troublesome of the false currents before mentioned. This current at times makes nearly at right angles to the axis of the channel, and runs directly into a number of dangerous rocks.

This reef projects into the channel at Hell Gate about 300 feet. The depth over it for a distance of 270 feet from shore is, at low water, less than 12 feet. The channel here being narrow and crooked, the object of this improvement is to widen and straighten it by securing a least depth of 26 feet of water over the reef.

Work was commenced in July, 1869, by building a coffer-dam between high and low water marks. In October following, the excavation of the shaft was begun. From the bottom of the shaft ten tunnels were driven under the river in radial lines, and were extended until a depth of water upon the reef of 26 feet at low tide was reached, the roof of the excavation being kept nearly parallel to the bed of the river, and about 10 feet below it. The main tunnels are about 14 feet in width, varying from 10 to 22 feet in height, and averaging about 270 feet in length. They are connected with each other at intervals of 30 feet by means of cross-tunnels or galleries of about the same height and width. Between the tunnels and galleries large columns

of solid rock were left to support the roof of the excavation, or bed of the river. These large columns were afterwards cut through by other tunnels and galleries, until finally 173 piers were formed averaging about 10 feet each in thickness. The entire reef, covering an area of 3 acres, is thus undermined. The aggregate length of tunnels and galleries driven under the bed of the river is 7,425 feet. From the excavation 47,461



Ground plan of the work at Hell Gate.

cubic yards of rock have been removed by drilling and blasting. This operation required 208,174 linear feet of drill holes, of which 90,107 feet in depth were drilled by hand, and 118,067 feet by various kinds of machine-drills, viz, the Burleigh, Diamond, Rand, Winchester, Wood, Ingersoll, and Waring drills, worked by compressed air.

The following quantities and kinds of explosives were used in blasting the rock: Blasting powder, 24,431 pounds; nitro-glycerine, 26,471 pounds; giant powder, 1,932 pounds; mica powder, 600 pounds; vulcan powder, 4,017 pounds; rend rock, 1,500 pounds. In exploding these compounds, 63,756 exploders and 331,516 feet of Bickford's safety-fuse were used. In all about 75,000 blasts were fired. The usual method of driving a tunnel was as follows: The face of the rock was pierced obliquely with as many drill holes from 3 to 4 feet in depth as were deemed necessary. The charges were then prepared by placing the explosive in water-tight paper cartridges from 8 to 12 inches long, and containing from 8 to 12 ounces of explosive; into each of these cartridges would be inserted a copper cap (containing mercury fulminate), fastened to the end of a piece of safety-fuse generally about 5 feet in length. The cartridge was then pushed to the bottom of each hole, which was filled with water. The ends of the fuses, hanging from the drill holes, were then ignited. The broken rock was then loaded upon small cars, carrying about one-third of a cubic yard each, which were hauled by mules along a railway to a turn-table near the middle of the floor of the shaft, where a derrick worked by steam hoisted the car body and its contents off the truck to the top of the shaft, and the rock there dumped into a tipping car attached to a small steam locomotive, which conveyed the *débris*, and deposited them

at the end of the dump pile. The excavations were completed in June, 1875, and since that period the piers and under surface of the roof have been pierced with numerous blast holes to effect the final demolition.

The excavation of Flood rock, a large reef in the channel, has been already commenced upon the same principle as applied at Hallet's Point.

No. 2. Model of steam drilling scow, as designed and constructed by Bvt. Maj. Gen. John Newton. Scale 1 to 24.

This machine consists of two parts, a large float or scow, having a well-hole in it of a diameter of 32 feet. It is built very heavy and strong, and is provided with an overhang or guard around it, faced with iron, and has proved itself, up to this time, capable of withstanding violent collisions with other vessels. Besides affording this security, it serves also to transport the caisson, or dome, from place to place, and is a working platform from which the drilling engines are operated. The caisson, or dome, is a hemisphere of the diameter of 30 feet, composed of a strong iron frame covered with boiler iron. The dome is open at bottom and at top, and is provided at the bottom with legs to support and level it, which are arranged to be let go altogether after the dome is lowered. Owing to the hemispherical shape of the caisson, the pressures of the moving mass of water which are normal to the surface necessarily pass through the center, and there is consequently no tendency to an overthrow by the action of horizontal currents, but, on the contrary, an additional, downward pressure favorable to stability is produced.

The caisson, or dome, is simply a framework, affording a fixed support to twenty-one drill-tubes through which the drills operate. The dome is connected with the scow by four chains communicating with four hoisting engines, by which it is lowered or raised. A framework is built upon the scow around the well-hole, to support the carriage holding the drill engines, which by these means may be placed directly over the drill tubes. The engines simply raise the drill rods, and allow them to fall by their weight upon the rock, the vertical play being 18 inches. The drill and drill rods together are about 10 feet long, and weigh from 600 to 700 pounds. The cutting edges are in the form of a cross, and are 5¼ inches long.

The scow, having the dome swung by chains, is first anchored over the rock to be operated upon, so that the bow and aft moorings pull against the direct currents of the ebb and flood tides; but as these may vary somewhat in direction from one tide to another, as well as during the course of the same tide, it becomes necessary, in order to steady the scow, to have side anchors also. The diver descends to ascertain whether the location is well suited to placing the dome on the bottom, and, if not, to select a better. The required change in the position of the scow is made by lengthening and shortening the mooring chains with capstans, which are arranged to be worked, at will, with steam or man power. The dome is then lowered, and when it touches or approaches near the bottom, the legs are let go by the run, and, being held by self-acting cams, support the weight of the dome. The chains are now unslung from the dome, which is thereby without connection with the scow. The diver descends to ascertain which of the drill tubes it is necessary to use to break up the rock within the dome, and how the surface offers itself to each particular drill. The drill rods being introduced within the drill tubes—which is easily effected during the most violent currents—a rope or other flexible connection is now made between the top of the drill rod and the piston rod of the drilling engines. A flexible connection is necessary to the act of drilling, as in this machine, the dome remaining fixed upon the bottom in one position while the scow holding the drill engines swings for short distances from changes in the directions and strength of the currents, no rigid connection between the engine and drills would be practicable. The length of the rope attachment is regulated by a feed-gear for the rise and fall of the tides and continual changes of water-level.

The drilling being completed, preparations are made for charging the holes with nitro-glycerine. The chains are hooked on the dome, which is then raised from the bottom, and the scow swung off from the spot to a safe distance without casting loose the moorings. This distance will depend upon the proposed amount of charge of nitro-glycerine, and will vary from 175 to 350 feet. The nitro-glycerine in tin cases of different lengths to suit the varying depths of the drill-holes, is carried to the spot upon a small scow, from which the diver descends to the first hole to be charged. He is guided to this by a line. Withdrawing the plug, he introduces into the hole the tin cartridge, which has been filled by the men on the scow and passed down to him. Each cartridge is attached, before it is sent down, to the wires. The diver then passes on to the second hole, guided by the plug line which connects the stoppers of the adjacent holes, and in this way the whole circuit of holes is visited and charged. The leading wires are connected with the battery, when the small scow has been withdrawn, and the explosion is made.

To break up the rock thoroughly the drill-holes should be from 6 to 8 feet apart, of the size of 5½ inches at top, with the usual tapering towards the bottom, and charged with amounts varying with the depths of hole, which will average between 50 and 60 pounds for each. Under these conditions the depth to which the drill-hole reached below the level to which it was desired to break the rock was about 4 feet.

After the rock broken by the explosion covers the greater part of the reef its removal is commenced. This is effected by means of a steam-grapple.

By this machine Way's Reef at Hell Gate and Coenties Reef in East River have been removed to the depths of 26 and 25½ feet, respectively. It has also operated upon Diamond Reef, East River, and Frying Pan and Pot Rock in Hell Gate, and removed portions of these reefs. A channel has been cut by the same machine through a reef in the Harlem River.

Since this model was constructed some changes have been made in the machine itself, but only in details of hoisting machinery on the deck of the scow, and not at all affecting the dome or caisson which is the distinctive feature of the machine.

A single traveling derrick has been substituted for the four ordinary ones shown in the model, which were carried away by a collision.

No. 3. Models of gabions used in construction of jetties at Galveston, Tex., scale 1 : 12. Contributed by Captain Howell, Corps of Engineers, brevet major, U. S. A. See also in connnection the photographs and views which accompany the models (Class A, No. 38).

This work, which originated in a series of experiments and has since been vigorously prosecuted with most excellent results, is chiefly interesting as indicating a method of utilizing otherwise useless material in the construction of submerged piers or jetties possessing the important advantages of strength, durability, and stability.

The plan of this work and the manner of constructing the gabions was proposed by Capt C. W. Howell, Corps of Engineers, in a report of December 30, 1873.

A Board of Engineers, convened for the purpose, reported in the following February, upon Captain Howell's project, indorsing his views with regard to the feasibility of employing piers, and with regard to the peculiar construction proposed by him, recommending that a trial be made before entering upon the work. The point in question was the stability of the gabions or capacity to resist the action of the currents tending to drive them from their positions.

The experiments made sufficiently demonstrated the stability of the gabions, they being found to stand in a position where 30-foot piles, sunk half their length in the sand, had failed.

The jetties are formed by placing gabions end to end along the proposed line. The gabions are 6×6×12 feet long and consist of a wooden top and bottom, connected by upright pickets covered with a wattling of sea cane, and a thick coating of cement

laid on the wattling. The first gabions were 6 feet diameter and 6 feet high, and were placed in two rows side by side to form a tier, but the second row was soon abandoned as unnecessary, and the circular gabions subsequently gave place to the oblong ones above described. The crevices at the ends of the gabions are stopped by cane fascines, held in place by concrete weights. The bottom is protected from the action of rebounding currents by aprons of sea cane, laid on each side of the gabions and loaded with concrete blocks. Spurs are run out at intervals at right angles to the general line, to destroy the longitudinal currents when any exist. A bar immediately begins to form behind the gabions and soon grows to the top of the tier.

Upon the crest of this bar, resting half upon the sand and half upon the lower tier, a second tier may be laid if necessary, and the same construction may be repeated till the surface is reached. The construction of the gabions is thus described by Lieutenant Quinn, the officer in superintendence, in one of his reports: "A bottom of 2-foot plank is first made; this is taken to the weaving-ground, when the stakes are placed in the holes bored for their reception; a form is placed at the top of the stakes to hold them in position; the wicker-work is then commenced and carried half way up, when four cross-wads are fastened in place by galvanized iron wire; the top form is then removed and the wattling completed; a ballast of concrete is then laid evenly over the bottom and carefully rammed; a plank top is then put on the gabion and the stakes securely nailed to both top and bottom; two ¾-inch iron bolts pass through the top and bottom and bind the whole securely together; the outside is then carefully covered with two coats of cement plaster, after which the gabion is allowed to stand two weeks before it is considered ready for sinking."

The cost of materials and labor for the construction of a single gabion, including the fascines and protection mats, is $42.53. The cost of a gabion in position is $62.53, making the cost of the pier per running foot $5.21.

This estimate was made in the experimental work and can probably be reduced with skilled labor and materials in large contracts.

The project contemplates 37,000 feet of jetty, two tiers high, and 20,000 feet of spar jetties one tier high, at a total cost of about $560,000.

The official reports on this work, giving full details, are to be found in the Report of the Chief of Engineers for 1875, Part I.

No. 4. Model of dredging apparatus on U. S. dredge-boat McAlester. Contributed by Capt. C. W. Howell, Corps of Engineers, brevet major, U. S. A.

The Government owns two boats of this pattern, one of which, the Essayons, was built in 1868, and entirely rebuilt in 1876. The other, the McAlester, was built in 1872. The design of these vessels was by the late General McAlester; Corps of Engineer

The dredging attachment or "deflector" is the device of Captain Howell and has been placed on both boats. Captain Howell in building the McAlester, also made a number of improvements in the dredging machinery. The "deflector" consists of a curved or scoop-shaped shield of iron, about 20 feet wide and 12 feet deep at the middle. The deflector is attached to two iron arms about 30 feet long, and the arms are fastened to the sides of the vessel at points about 25 feet from the bow rudder post, and 20 feet below the water line, giving the deflector a rotation about an axis passing through these points. The deflector is raised and lowered by a chain passing over a pulley to a capstan called a "wild-cat" connected with the forward hoisting engines. The vessel is provided with two screws, the forward one being the excavating screw, and is accompanied by the deflector.

The boat is operated as follows: Being below the shoal to be operated upon, with the deflector raised, she is run up stream on the bar, as far as desirable, and stopped. The deflector is then lowered until it sinks a foot or two in the mud or sand, when

the excavating screw is set in motion backwards. This screw loosens the mud and throws it against the deflector, which, being at an angle with the perpendicular, sends it into the upper current, which carries it down stream, and it is deposited in deeper water.

No. 5. Model of end dock, for docking United States dredge-boats at the mouth of the Mississippi River, with pumping machinery. Designed by Capt. C. W. Howell, Corps of Engineers. Contributed by Capt. C. W. Howell, Corps of Engineers, brevet major, U. S. A.

This dock is thus described by Captain Howell, in his report, September 10, 1873:

"A new end dock was completed July 5, for the use of the McAlester and Essayons.

"This dock is, I believe, the largest of its kind ever built, and has some novel features deserving mention.

"The after end is filled with water-tight bulkheads forming three compartments for water ballast, by the use of which the vessel docked is relieved from much of the strain incident to the use of end docks.

"Ballast can be added or pumped out as called for by the removal or replacement of heavy machinery and all change of strain avoided.

"The facility with which this is done with water makes its use a great improvement over the old method of putting in each end stone or iron ballast. The after end has also been fitted with a long box or trough by which the propeller shaft can be taken out of the ship and replaced when repaired. The shaft of the McAlester, 24 feet long and 15 inches diameter, has just been taken out in this way, with as great care as could have been done in a dry-dock.

"This novel and useful feature fits the end dock for doing all repairs except to the hull amidships and below the water line, a portion of the dredges only needing repairs once in two or three years. The open end of the dock has been fitted with a complete set of molds for the dredges, so arranged that they can be exchanged in a few hours.

"Molds for other steamers and ships cruising to this port can be arranged in the same way."

No. 6. Model of sounding machine. Contributed by Colonel Macomb, Corps of Engineers, U. S. A.

An apparatus for obtaining and recording soundings with greater rapidity and accuracy, and at less expense than by other methods. Has been used for some years in the improvement of Rock Island and Des Moines Rapids of the Mississippi River.

In general surveys of portions of river by the use of the machine large numbers of soundings are made at regular intervals, with no wide gaps as are customary in skiff soundings, so that superior hydrographic maps are obtained, which accurately define the channel and give a perfect representation of the river bottom. In rock excavations coffer-dams may be properly located, or where chisel and dredge or the various methods of submarine blasting are employed for removing smaller patches of rock than it is customary to coffer-dam, the quantities of rock removed can be actually determined. This machine was designed and constructed by Maj. E. F. Hoffmann, assistant engineer, under supervision of Col. J. N. Macomb, Corps of Engineers, U. S. A.

The general scale of the model is in the proportion of 0.085 to 1 of the original. The lateral scale of the sounding boxes and poles is double the above, it being found inexpedient to show the details of the same on so small a scale. The scale of the recording apparatus is also doubled. In the model the distance which the sounding poles descend is to the length of line shown on the record in the proportion of 15 to 2, but in the machine itself 15 to 1.

The body of the machine consists of five small flat-boats, one of which is somewhat

larger than the others, combined as shown in the model into a system 100 feet in length. This system is attached to the bow of a light-draught steamer, at right angles to her center line, by means of two diagonal spars, so as to place the apparatus completely under her control and insure a steady, uniform motion at any rate of speed desired.

Upon this system of boats is erected a frame-work of masts stiffened by guy-rods, which carries the sounding boxes and poles, ten in number, at intervals of 11.1 feet.

The power for working the apparatus is transmitted from the steamer by means of a steam capstan (in the model a crank is substituted for convenience). This runs a line of shafting, passing through the lower ends of the sounding boxes, on which shafting are the wheels which carry the chains which draw down the sounding poles. The poles on striking the bottom displace a lever arm, thus bringing a counter weight running in the sounding boxes into play, which draws the pole back to its original position. Should the water be deeper than the length of the pole, on reaching the full length, the lever is struck by a fixed arm on the sounding boxes and the pole returns as before. (This latter attachment not shown in model.)

To insure a perpendicular motion of the poles in their descent cords are attached to their feet, which cords pass around wheels on a line of shafting laid along the bows of the flat-boats. This shaft is run by a pair of screw wheels on the main shaft, the peripheries of which wheels are so adjusted as to give just sufficient line to each pole to insure perpendicularity at whatever depth it may descend.

On the axes of the wheels at the tops of the sounding boxes are screws, the dimensions of which are such that the periphery described by a point in the thread of the screw in one revolution is in proportion to the periphery of the wheel itself as 2 to 15, so that for each 15 inches of descent made by the pole, the line passing around the screw will be wound up 2 inches. In the machine small pulleys are used instead of screws, and the proportion is as 1 to 15.

The lines passing around these screws are conducted by small pulleys and made fast to the upper ends of small steel rods, ten in number, each rod corresponding to one of the poles. These rods run on small sharp-edged wheels pressed firmly against white paper, on which paper as the poles descend marks are made proportional in length to the distance of descent of the corresponding pole. This series of marks constitutes the record, and may subsequently be reproduced in figures by means of a scale prepared for the purpose.

The mode of locating the soundings made by the machine is as follows:

On the shore at both ends of a measured base line are two men with theodolites. At the instant of sounding, the signal (in the model represented by a brass ball) is run up, this being accomplished by a line passing over a wheel run by the main shaft. This signal, the center of which is in a line with the sounding poles, is covered at the same instant of time by the cross-hairs of the theodolites on shore. Thus the one end of the system of boats is located. Another man with theodolite is stationed on the same end of the apparatus, who at the instant of sounding takes the angle representing the difference of direction of the center line of the system of boats and a line from his instrument to one of the instrumental stations on shore. The relative positions of the poles, the signal and the theodolite on the boats being known, the location is complete.

Although the machine is capable of making six dips a minute, or sixty soundings, yet, as the theodolite observers cannot without great labor make more than three observations per minute, for any protracted length of time, the operation of the machine is restricted to three dips, or thirty soundings, per minute. This would give, making allowance for the usual delays, about 10,000 soundings per day. By means of a skiff about 1,000 per day can be made. The advantage, then, in point of time of the machine over skiff soundings is as 10 to 1. In preliminary surveys, or where great accuracy of location is not required, the full quota of 6 dips per minute may be made by interpolation, and 20,000 soundings per day can thus be obtained.

The following table shows the advantage per day of the machine in point of expense:

SKIFF.		MACHINE.	
2 theodolite observers, at $4	$8 00	Hire of steamer (including men and coal)	$36 00
2 boatmen, at $2	4 00	1 pilot	5 00
1 sounder, at $2	2 00	3 theodolite observers, at $4	12 00
1 flagman, at $2	2 00	1 machinist, at	3 00
3 recorders, at $1.33⅓	4 00	1 assistant machinist, at	2 00
		4 recorders, at $1.33⅓	5 33
Total per day	20 00	Total per day	63 33

By skiff 1,000 soundings per day, at $20, would give 2 cents per sounding.

By machine 10,000 sounding per day, at $63.33, would give about .63 of a cent per sounding.

Or the advantage of the machine is about 3⅓ to 1 in point of expense.—Colonel MACOMB.

No. 7. Model of section of breakwater at Dunkirk, N. Y. Contributed by Lieutenant-Colonel Blunt, Corps of Engineers, brevet colonel, U. S. A., for Major Harwood, Corps of Engineers, brevet lieutenant-colonel, U. S. A.

This structure stands in 8 feet water on a nearly level foundation of compact slate. The particular difficulties to be encountered in its construction were:

1st. The liability to destruction of incomplete work by the violence of heavy incoming waves which suddenly arise and attack the work within a few hours with little previous warning.

2d. The tendency of the structure while thus attacked to slide out of position over the smooth slate surface of its foundation.

Several previous structures or sections of breakwater having been from time to time destroyed or displaced from these causes, the breakwater of which this is a model was designed by the engineer officer in charge of the public work at this harbor to meet and overcome the difficulties above mentioned, and has thoroughly succeeded in so doing, 818 feet of breakwater having been built from 1871 to 1875, inclusive, all of which is intact and has required no repairing nor met with any serious disaster in construction.

The peculiarities of the design are:

1st. The grillage deck, whereby the loss of one, or even several, planks during a gale of wind does not endanger the whole superstructure or a greater or less section, as is the case in the ordinary system of frame deck.

Through the grillage deck, also, wastage or settling of the ballast can be remedied by a supply of beach rubble or gravel without the laborious and wasteful operation of taking off and replacing more or less planking. It is found by experience that the heaviest seas washing over the breakwater effect no material wastage through the grillage deck, but that the sea has its force effectually broken and is dispersed by the grillage spaces.

2d. The timber slope upon which the incoming wave of translation, which here rolls to the bottom of the lake, is received and divided at the water level, the horizontal thrust of the upper half is neutralized by the action of the reflux of the preceding wave, the submerged portion of the work alone opposing the maximum dimension to the attack of the remaining half.

Observe the thorough system of horizontal bolting whereby a continuous bond of the slope is effected, also the provision made for the thorough protection of the foot of the slope, which is otherwise the weakest point of the work.

3d. The interior longitudinal partition wall separating the slope sections from the body of the work and through which all ties and other cross-timbers are dovetailed, thus leaving a complete work 20 feet in width to oppose the incoming wave in the event of disaster to any portion of the exterior or slope section. This dovetailing was the happy thought of Mr. George E. Fell, assistant engineer.

4th. The grillage bottom, which is not claimed as an invention, being the same in form as habitually used in government works on the great lakes, but modified by substitution of plank for timber, diminishing expense and buoyant effort. Through this grillage the ballast is spilled to the lake bottom, forming a bond with it and opposing its friction to the tendency of the structure to slide over the smooth slate foundation as before noticed. This bottom was prescribed by the Board of Engineer Officers of 1870.—Colonel HARWOOD.

No. 8. Model of section of Breakwater at Oswego, N. Y. Contributed by Major Wilson, Corps of Engineers, brevet colonel, U. S. A.

This breakwater is constructed of timber cribs filled with stone. It is made of unusual strength to resist the great force of the lake waves (see No. 7 above).

The cribs are 35 feet square and of varying height. They are placed side by side and surmounted with a continuous superstructure, extending about 6 feet above low water. Great care was taken to fit the cribs closely to the bottom, and this with the interior bracing and a complete system of diagonal drift-bolting gives them great stability. The work is in charge of Maj. Jno. M. Wilson, Corps of Engineers.

No. 9. Model of United States shipping and landing pier at Lewes, Del. Contributed by Lieutenant-Colonel Kurtz, Corps of Engineers, brevet colonel, U. S. A.

The scale of the model is 1 inch to 1 foot; it shows one bay of the bridge and four bays of the head. The parts of the pier preceding and succeeding the model being of like construction, the whole may be described as follows:

The first forty-five rows of piles are 5½ inches diameter, with a length of 23 feet (except the three rows nearest the abutment whose lengths are 16, 18, and 20 feet respectively).

These have a single system of vertical diagonal cross-braces of 2-inch round iron, reaching from the cast-iron caps on the tops of the piles to the clamps, which are about 4 inches below mean low water; the next five rows are 5¾ inches diameter, and from 24 to 29½ feet in length, with the same kind of braces (the last row of these is the first of the model). At the commencement of the pier-head, which is 43 feet and five piles wide, there are three rows whose diameters are 6½ inches, and lengths from 31 to 33 feet, and have a double set of cross-braces; the upper ones like those described above, and the lower ones of 2½-inch round iron, reaching from the upper clamps to the lower set of clamps just above the bed of the harbor.

Commencing with the fourth row of the pier-head, or the fifty-eighth of the pier, the piles are 8½ inches diameter and about 55 feet long. (The second row of these is the last of the model.) They have the double system of cross-braces; the upper ones being 2¼ inches, and the lower ones from 2⅛ to 2½ inches diameter.

From the fifty-fourth row there is also a system of longitudinal vertical diagonal braces, under water, the diameter of which increases from 2½ to 3 inches.

The main stringers of the superstructure are of 12 by 12 inch sawed timber, 44 feet 6 inches long, with scarped ends. They cover two bays or three piles longitudinally; the outside timbers are single, the inner ones double, breaking joints, with a space of 1 inch between.

Over each transverse row of piles and notched to the main stringers, are two 9 by 9 inch girders with a 4-inch space between; these are secured by bolts passing through

them, the main stringers, and the cast-iron cap at each crossing. Between these are thirteen 4 by 9 inch beams set on edge, notched and spiked to the main stringers.

One side of the floor is planked with 3 by 6 inch stuff for wagons, and the other is arranged to carry on the bridge a single, and on the head a double, railway track.

No. 10. Specimens of iron used in the construction of United States Iron Shipping and Landing Pier, Delaware Breakwater harbor.

Hammered iron for shafts, turnbuckles, and bolts, to bear a tensile strain of 60,000 pounds to the sectional square inch.

Rolled iron for braces to bear a tensile strain of 60,000 pounds to the sectional square inch.

Cast iron for screws and caps to bear a tensile strain of 25,000 pounds to the sectional square inch.

No. 11. Model of derrick used at Lewes, Del. Contributed by Lieutenant-Colonel Kurtz, Corps of Engineers, brevet colonel, U. S. A.

The top of the derrick is but 23 feet above the platform or 37 feet above mean low water. Its special feature is an open jaw made by the two 6 by 12 inch timbers composing its jib. The carriage supporting the main chain sheaves is arranged to brace the two jib pieces horizontally.

To raise to a true vertical position one of the iron shafts 8½ inches diameter by 55 feet length (of which the pier-head is mostly made) the shaft is gripped one-third of its length from the head by an automatic "sling"; the head passes through the open jaw and projects above it, and the need of a high, heavy derrick is thus avoided.

No. 12. Model of clamp. Contributed by Lieutenant-Colonel Kurtz, Corps of Engineers, brevet colonel, U. S. A.

This instrument obviates the necessity of a key-way in or feather on the piles, or the use of set-screws, being automatic in clamping itself.

Above the usual casting containing sockets for the levers are three clamps working between two wrought-iron plates; the levers or arms of the cams are opened by the casting; the whole fits loosely over the pile; when this is ready to be screwed down the capstan is revolved, the plates being held stationary until the cams touch the pile, when the device tightens itself. The stiffer the soil penetrated, the tighter the instrument grips. It is loosened by reversing, and grips again to unscrew the pile when necessary.

No. 13. Model of automatic "sling." Contributed by Lieutenant-Colonel Kurtz, Corps of Engineers, brevet colonel, U. S. A.

The grip of the sling is made by two lever eccentrics working behind two chocks, which are curved to fit the pile. A bolt passes through the eccentrics and two band pieces which loosely hug the pile; the lifting chains are hooked into the levers of the eccentrics. In lifting the levers are raised and the eccentrics force the chocks against the pile. When slacked the instrument detaches itself.

No. 14. Model of harbor of refuge and vicinity, Sand Beach, Lake Huron, scale 1 to 2,500. Contributed by Major Weitzel, Corps of Engineers, brevet major-general, U. S. A., showing the general location of breakwater at this harbor. (See in connection Class A, No. 34.)

Sand Beach Bay, or Sand Beach as it is more commonly called, is in Huron County, Michigan, 60 miles from Port Huron light-house and 14 miles south of Point Aux Barques light.

The west coast of Lake Huron, from Point Aux Barques to the entrance to Saint Clair River, is entirely exposed to all northeast, east, and southeast gales, and even

strong north or south winds will make a heavy sea on that shore. The coast is exceptionally free from bays or points of sufficient magnitude to enable vessels caught out in gales to derive any benefit from their shelters and the necessity for an artificial harbor at some convenient distance south of Point Aux Barques has long been felt by vessel owners on the lakes. A vessel caught in a gale 50 or 60 miles from Port Huron light-house if unable to make Point Aux Barques, is either compelled to weather the storm in one of the most dangerous places on the whole chain of lakes, viz, the mouth of Saginaw Bay, or she must run back to the shelter of the Saint Clair River. It is a common thing for vessels to put back two or three times before being able to cross the bay. The expenses thus incurred by vessel owners is enormous during every season.

As a properly located harbor of refuge would obviate all of this, and as the proposed work would be of inestimable value to almost the entire commerce of the lakes, Congress was asked to make an appropriation for the work. Accordingly on March 3, 1871, an appropriation of $100,000 for the commencement of the work was granted. Under the direction of Maj. O. M. Poe, Corps of Engineers, brevet brigadier-general, U. S. A., examinations and surveys were made at three points, viz, Port Hope, Sand Beach, and Blue Ledge, with a view to determine which of them offered the greatest advantages for the proposed harbor.

The surveys were very minute in their character, and were not completed until the end of August, 1871. Neither of the three above mentioned points appearing to satisfy all the conditions of a good site, General Poe, on September 30, 1871, suggested that a Board of Engineer officers of high rank be convened for the purpose of definitely selecting a site for the harbor. The request was granted, and the following officers directed to meet in Detroit on the 19th of October, 1871: Col. J. N. Macomb, Lieut. Col. I. C. Woodruff, Maj. C. B. Comstock, Maj. O. M. Poe, and Maj. F. U. Farquhar, all of the Corps of Engineers, U. S. A. The Board were ordered to visit two localities, Port Hope and Sand Beach, and to especially examine into the extent and nature of their holding grounds. They were also directed to ascertain the views of persons engaged in the commerce and navigation of the lakes, and to report fully upon the most suitable site for the harbor of refuge, its plan, the form, dimensions, and mode of construction of its breakwater or piers, and to accompany the same with an estimate of cost of its construction.

The Board met October 19, 1872, pursuant to orders, and after numerous sessions, extending through an entire year, decided that the results of the numerous examinations and surveys made at their suggestion showed that all other points than Port Hope and Sand Beach offered so little encouragement that it was not deemed necessary to discuss their relative merits, and as between Sand Beach and Port Hope there appeared to be nothing either in the geographical position or nature of the anchorage to give a decided preference to either, the Board concluded that the question of location was practically reduced to one of cost.

At Port Hope, in order to secure the harbor deemed necessary, a breakwater of 10,000 feet in length would be required. At Sand Beach the same shelter could be obtained by a breakwater 7,000 in length. The cost of construction being so largely in favor of Sand Beach, the Board selected that place for the proposed harbor, and submitted plans and estimates for the work.

Their plans called for a continuous line of breakwater nearly 7,000 feet in length. A point was selected about 3,000 feet from shore and in 20 feet of water. From this point the construction was to begin, the first crib being an angle crib, with its two sides making an angle of nearly 148°, and to be so placed in position that the sides would run in west-northwest and southeast directions, respectively. The first to be extended till, at the end of 2,325 feet, it should reach the shore. The side running southeast to be continued a distance of 3,900 feet.

The estimated cost of the harbor was $1,452,500 for a length of about 7,000 feet. The report of the Board was approved, and proposals for the work, as far as the funds available would permit, were advertised for under date of April 19, 1873.

Maj. G. Weitzel, Corps of Engineers, brevet major-general, U. S. A., relieved General Poe on May 1 following, and since then has been the engineer in charge of the work. On May 20 the proposals were opened and the contract awarded to Messrs. Dale & Davidson, of Chicago. The construction of the breakwater to form the harbor proposed is essentially the same as is used in similar works on the lakes. It consists of cribs of timber bolted with iron filled with ballast stone and planked on top. The cribs are sunk to a foot or two above the level of the water, and after being allowed to settle, the superstructure, a continuous work, is put on. The breakwater is protected from floating ice on the outer side by iron sheeting 4 feet wide, the upper edge being placed 1 foot above the level of the water. Snubbing or mooring posts are provided every 20 feet, and at the same distance apart on the inner face ladders are placed flush with the surface of the cribs, to enable persons to reach the deck of the breakwater from small boats.

A pier light (white fixed) of the fourth order has been built by the Light-House Department on the angle crib, and upon the completion of the breakwater another will be placed at the extremity of the southeast wing. In the first plans proposed both the longitudinal and cross walls of the cribs were to be built up solid. This plan was changed, however, before any cribs were built, and every alternate timber left out of the cross walls. The object of this change was to allow the ballast stone to arch over and settle in between the cross-ties, and by its weight on them to materially assist in keeping the crib in position. The plan has worked admirably. No trouble whatever has been experienced from the shifting of the cribs.

In the north wing of the breakwater, and at a distance of 325 feet from the angle, an opening of 300 feet has been left to facilitate the ingress and egress of vessels. It is hoped that the sea admitted by this will not materially affect the smooth water inside, and the opening will certainly materially assist vessels in reaching and leaving the harbor. If it is found necessary to close it it can be done at any time.

At this date, June 27, there are in place twenty-seven cribs 65 feet long, 38 feet wide, or a length of 1,755 feet; twenty cribs 25 by 50 feet, equal to 1,000 feet, and ten cribs 18 by 45 feet, equal to 450 feet. This gives a total length of 3,205 feet of breakwater, of which all but 195 feet at the southeast end is entirely completed.

The total cost of the work thus far has been about $350,000. This length of breakwater furnishes of itself a good harbor for vessels, and during the last season was extensively used by vessels, as many as 40 being safely anchored behind it at one time. An accurate chart of the harbor and its approaches has been prepared by the United States Lake Survey, and will be ready for issue soon.—General WEITZEL.

No. 15. Model of angle crib of the breakwater above described, scale three-eighths to one inch. Contributed by Major Weitzel, Corps of Engineers, brevet major-general, U. S. A.

This crib (in two parts) was the first sunk, and stands in 22 feet of water. The sides of the cribs and the longitudinal partitions are solid, and the transverse partitions are open, being of 12-inch timber, placed 12 inches apart. For the superstruction the crib-work is carried up and made continuous. The outside, from low water up, is strengthened and protected by a tier of 12-inch timbers, placed vertically, strongly fastened to the crib, and connected by strong pieces at the top and near the bottom. Over the whole a deck of thick plank is laid. The vertical timbers are further protected from ice and driftwood by an iron plating at the water level.

A light has been placed on the angle crib, as shown in the model.

No. 16. Model of a crib. Contributed by Maj. D. C. Houston, Corps of Engineers, brevet colonel, U. S. A.

The timber generally used is pine, 12 inches square, secured by iron drift bolts. The bottom of the crib is formed of a grillage, leaving openings to allow the stone filling to pass through when sand is washed out from under the crib, thus preventing the

tilting of the crib, which would otherwise occur. This does not perfectly accomplish the desired object, and various methods have been designed to prevent the unequal settlement and displacement of cribs. I have sent a few copies of "Method of Sinking Cribs" devised by me, which has been successfully adopted at several harbors.—Colonel HOUSTON.

This method of sinking cribs, devised by Major Houston, is considered of sufficient importance to be inserted here, as described by him:

"Six piles are driven on each side of the site of the crib, in pairs, as shown in the drawing and perspective view. The piles are capped with a stick of oak timber, running the whole length of the crib. The crib is built in three compartments by partitions running lengthwise. The middle compartment has a close bottom, about 13 courses below the top. The outer compartments have entirely open bottoms, or may have a single longitudinal stick, as shown in the drawing. In the cribs sunk at Chicago they are entirely open, which is considered preferable. Chains are attached to the lower cross timbers of the crib, three on each side. The chains are made of sufficient length to enable them to be securely fastened to the oak timber between each pair of piles, when the crib is lowered to its required position. The piles having been driven and capped and the crib framed, the latter is lowered to its position and weighed down with stone, until its bottom is (say) 4 feet above the bottom of the lake. The chains are then secured to the oak timbers in the manner described. The upper end of the chain is provided with a hook which will pass through any link.

"It was found desirable to take two turns of the chain over the oak timber. This prevents any further settlement. The filling then proceeds, care being taken not to put too much stone in the middle compartment, to bring too great a strain on the chains until the outer compartments are filled. These outer compartments, having open bottoms, allow the stone to pass through freely. Foundations are thus formed on which the crib rests. In case of any undermining the stone passes down without taking the crib with it, and thus prevents any displacement or settlement of the crib.

"The stone in the middle compartment, which has a close bottom, does not move, and is sufficient to secure the crib in its place in case of storms, and prevents the possibility of the crib rising by the sifting of the stone through the grillage bottom, as has sometimes occurred. It is considered that the bottom of this middle compartment may be nearer to the top of the crib.

"The crib thus remains in the position in which it was originally placed, and the superstructure can be put on at once. Three cribs have been placed in this manner in the Chicago breakwater, and so far successfully. After a crib has been once placed and filled in this manner it is not seen how it can be displaced.

"This method is adapted to all soft or sandy bottoms where there is a tendency to undermine. It insures a close fit of the cribs, and a perfect alignment, and avoids the difficulties and expense of leveling up and otherwise arranging for superstructure.

"This method has also the advantage of securing the crib during the process of sinking. The additional cost of the piles, &c., is more than compensated for in the diminished amount of timber and stone required, and the reduced cost of putting on the superstructure. The superstructure need not necessarily be continuous. Additional stone should be thrown in on each side of the crib."

No. 17. Model of pile pier. Contributed by Major Houston, Corps of Engineers, brevet colonel, U. S. A.

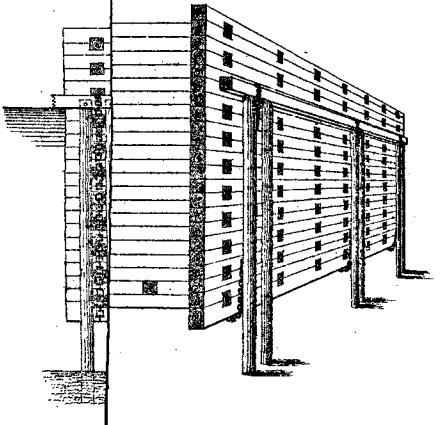
This is a cheap method of construction adopted at harbors of minor importance or where the funds provided are limited. It consists of two parallel rows of piles driven into the lake bed. These piles are cut off at the water level and the two rows tied

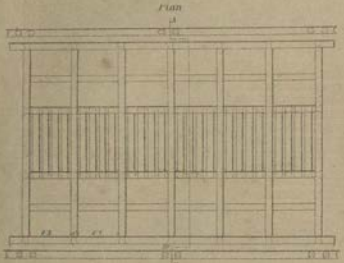
N

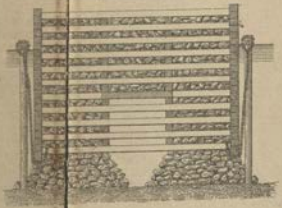
BREAKWATER

d of sinking

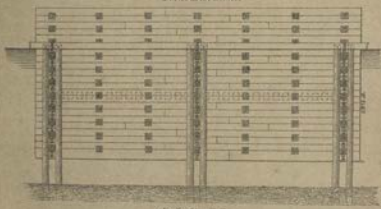
N, Corps of Engineers U.S.A.

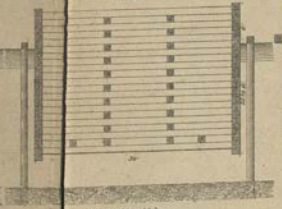


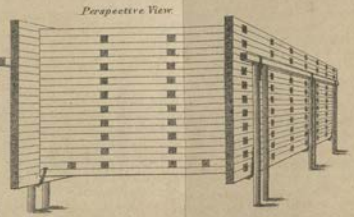




PLAN
of
CRIB IN CHICAGO BREAKWATER
Showing method of sinking
devised by Major D.C.HOUSTON, Corps of Engineers U.S.A.
1873.







together near the top. A superstructure of timber is built on the piles, and the whole filled with brush or slabs (refuse from the saw-mills), loaded with stone.

These two models show the general character of harbor constructions on the Great Lakes. Many modifications of the crib and pile constructions have been made, and there is still room for improvement, especially in the pile pier.

No. 18. Model of a grapple. Contributed by Major Merrill, Corps of Engineers, brevet colonel, U. S. A.

The grapple of which I forwarded a model is the one used in the Ohio River for the removal of large bowlders from the bed of the river. Before it was built various kinds of clam-shell grapples and dredge-buckets were examined, but all seemed unsuited to the special circumstances of the case on account of requiring separate drums for lowering and for hoisting. This was objectionable, because it was necessary to obtain a grapple for service with the hand-power crane-boats that are in common use on the Ohio, which have only one hoisting drum, being used to lift heavy articles that have been previously chained.

This grapple is opened while being lowered over a bowlder by simply taking a turn around a cavil with the opening rope, and holding this rope fast until a sufficient width of opening is obtained. The grapple is thus opened by its own weight, after which both hoisting chain and opening rope are lowered together until the grapple is in position for raising the stone. The act of hoisting brings the fingers of the grapple under the bowlder, which is lifted as in a basket.

It was thought best to use the simple system of levers shown in the model, rather than the compound systems used on clam-shell dredges, in order to avoid the severe strains on the members that are developed in other systems where the fingers cannot close under the stone to be lifted. It is not expected that this grapple will lift embedded bowlders; the latter are invariably first broken up by blasting.

This grapple has been used with great success on the Ohio and Kanawha Rivers. The only drawback to its steady use comes from the rivers themselves, which are almost always either too high or too muddy for work of this character. It is therefore necessary to so arrange matters as to be able to begin and end work at a moment's notice.

The capacity of the grapple is 15 tons. Its weight is 2,700 pounds. It should be added that the actual grapple has four fingers on each side instead of three, as shown in the model, and also differs from it in some minor points; the model was built from the designs prepared for a second grapple, and therefore contains the improvements suggested by experience with the first.—Colonel MERRILL.

No. 19. Model of the extreme portion of Cape Cod. Contributed by Lieutenant-Colonel Thom, Corps of Engineers, brevet brigadier-general, U. S. A.

Horizontal scale, 1 to 20,000; vertical scale 1 to 1,000.

The model of Provincetown Harbor was prepared under the direction of Colonel Thom, in 1872, by Mr. Sophus Haagensen, civil engineer, for the purpose of showing at a glance the configuration and formation of the northern extremity of Cape Cod, and the several places where the harbor of Provincetown has hitherto been exposed to injury and even to destruction; also, the several dikes, bulkheads, jetties, and other works that had been built up to 1872 for its protection and preservation, with the benefits resulting therefrom.

From 120 feet to 30 feet below mean low water the model is constructed from Colonel Graham's map of 1835; above the 30-foot curve surveys made under the direction of Lieut. Col. George Thom have been used.

White painted part of the bottom indicates clear sand; dark gray bottom, stiff mud; brown colored part, soft mud; blue painted part indicates limits of rise and fall of tide; green indicates salt marsh.

Above the high-water line the topography is not represented.

East Harbor Pond and Salt Meadow are fresh since the construction of the State dike at Beach Point and the United States dike at High Head.

The construction of the United States dike at Abel Hill has stopped the flow of tide from Lancy's Harbor into Provincetown Harbor.

No. 20. Model of the hull of United States snag-boat Macomb. Contributed by Maj. Charles R. Suter, Corps of Engineers. (See Class A, No. 75 to 79.)

No. 21. Model of grapple and derrick used in New York Harbor. Contributed by General Newton.

No. 22. Mattress or apron across New Inlet, Cape Fear River, North Carolina. Model contributed and work in charge of Colonel Craighill, Corps of Engineers.

The following history of the work, consisting mainly of extracts from an "Historical Sketch of the improvement of the Cape Fear River, North Carolina," was kindly furnished by Captain Phillips, Corps of Engineers, assistant to Colonel Craighill:

"The New Inlet is located about 7 miles above the mouth of the Cape Fear River. The traditions of the country give the year 1762 as the date of the opening of the inlet.

"An article published in the London Magazine (December, 1761) gives an account of a violent equinoctial storm which commenced September 20, 1761, and lasted four days, during which the sea made a breach 18 feet deep at high water, and nearly half a mile wide, through the outer beach at a place called the Haulover. This was, no doubt, at the present site of the inlet. Tradition says that the famous storm referred to above was a "dry blow;" and it is easy to imagine that, under such circumstances, a depression might soon be made in the dry sand sufficient to permit of the trickling through of water *from* the river *to* the sea. It is not probable that the action of the waves upon the outer beach had anything to do with making the opening, but, on the contrary, their action would tend rather to restore and maintain the beach.

"A map of the Cape Fear River was published in 1794. At this date the inlet had been in existence over thirty years, and its effects upon the main bar were very manifest. On this map we find printed the words, "10 feet bar at low water." From the most reliable of the older maps there were at least 15 feet on the bar at low water before the breaking out of the inlet.

"In 1839 the bar had shoaled up to 8 feet of water at low tide, and continued to keep at about the same depth until the year 1853. During the latter year the first attempts were made for the improvement of the lower part of the river. This work continued from 1853 to 1858; but during this period no attempts were made to close or even contract the new inlet, but operations were mostly confined to the closure of several smaller inlets which had from time to time opened through the narrow beach immediately below the inlet (proper).

"From this time (1858) until 1870 nothing more was done for the improvement of the Cape Fear River. During this interval the bars at the main entrance continued to deteriorate; the eastern or main bar had been abandoned by shipping, having shoaled up to less than 7 feet, and through the western channel only 8 feet could be taken at low tide.

"The small inlets through Smith's Island had gradually enlarged, until they had united into one common passage over 1,400 yards in width, or equal to that of the new inlet itself, and separated from the latter by what appeared at high water to be a mere sand spit, known as Zeke's Island.

"In 1870 an appropriation of $100,000 was made by Congress for 'improving the Cape Fear River below Wilmington, N. C.,' and operations were commenced in September of that year.

"The main work consisted in constructing a line of crib work, with superstructure brought to above high water, entirely across the space between Smith's and Zeke's Islands. This work (4,403 feet in length) was completed on June 30, 1873, thus closing all the breaks through the Smith's Island beach, except the new inlet itself. A continuous sand beach has since formed on the outer or sea side of the work. Before reviewing the operations for the contraction of the inlet proper, it will be well to refer to one of the recommendations of a Board of Engineers on the improvement of the Cape Fear River, which was made at their final meeting in December, 1872.

"The recommendation referred to is as follows: '5th. That the closing of New Inlet is very desirable, and should be attempted as soon as funds are available; that with this object a jetty should be commenced from Federal Point, and follow the line of shoals in a general southwesterly direction, as indicated on the latest map.'

"In accordance with the above recommendation, work upon the jetty was commenced during the very early part of July, 1873. It was decided to construct the first 500 feet of the jetty of cribs similar to those at the old work; it being the intention to afterward adopt some simpler and cheaper form of structure. As the work progressed a very serious deepening occurred in advance of the line of cribs. By the time 200 linear feet of cribs had been placed in position, cribs 12 feet in depth were required where there were originally only 6 feet of water, and when the last crib (completing the 500 feet) was placed in position, it was sunk in 19 feet of water, the original depth having been only 6 feet.

"It was now determined to go no farther at present with the jetty, either in its present or any modified form of structure, but to wait until the effects of the work should develop themselves.

"At the beginning of the fiscal year 1875-'76 the 500 feet of jetty at Federal Point had been standing for a period of eighteen months. Its effects upon the inlet and upon the river below had been carefully watched, and no new developments were anticipated. During this interval a new channel had been cut behind the Horseshoe shoal, on the opposite side of the river. This channel was standing well, and was drawing a large quantity of water away from the inlet, and toward the western side of the river, and the time seemed ripe for attempting a further contraction of the inlet.

"Proposals were accordingly invited for continuing work at the inlet, either by undertaking the closure of the inlet as a lump job by extending the old jetty to a specified length, or by constructing an apron entirely across the inlet. In case bids were to be made for the latter, bidders were to be governed by drawings (made under the direction of the officer in charge of the work) showing plans and sections of such an apron as seemed to the Government to be desirable, referring to dimensions only and not specifying the class of material to be used.

"After some delay, caused by the rejection of one entire set of proposals, a contract was, on the second opening of bids, awarded to Messrs. Bangs & Dolby, of New York State, for the construction of an apron entirely across the inlet. The apron was (in accordance with the Government drawings) to vary in width with the depth of the water at the various points on the proposed line of work. This gave at the deepest water a width of 70 feet; at the shoalest, a width of 40 feet; average width, 53 feet. This width was such that if the structure were brought up with a slope of one on two on the sea side, and one on one on the river side it would have a width of 16 feet at ordinary low-water mark.

"The apron was to be 4 feet in thickness, and was to consist of one layer of round timber 1 foot in thickness, one layer of brush 1 foot in thickness, the remaining 2 feet to consist of stone.

"The apron was to follow the line laid down by the officer in charge of the work, and the contractors were to guarantee the permanence of the structure for the period of one year. The line laid down for the apron was a broken one, and consisted of three sections. The first, 920 feet in length, was on the prolongation of the line of the Federal Point jetty; the second, 1,588 feet in length, ran along the crest of the 6-foot

shoal, in a direction nearly tangential (a little outside) to Zeke's Island; the third, 1,844 feet in length, crossed the inlet channel, and rested on the shore of the island at the site of Woodbury's old wharf; total length of apron, 4,352 feet.

"The contract for the execution of the above work was dated August 25, 1875. Work was commenced early in October, 1875, and the entire work satisfactorily completed about the middle of June, 1876. The apron consists of successive rafts or mattresses of timber and brush sunk in juxtaposition on the line of work. The mattresses average about 40 feet in length, measured on the line of work, and in width, correspond with the required width of apron. The timbers are placed lengthwise *with* the current, or *across* the line of work.

"But little if any settlement occurred after a mattress was once in position. There was, however, a tendency to scour in advance of the line of work, so that the individual mattresses were sunk (on an average) in nearly 3 feet more water than the original soundings called for.

"In calculating the required width of apron, before the work was commenced, an allowance of 2 feet was made for the anticipated scour.

"There has also been a tendency to scour along both sides of the apron, particularly on the river side of the second section. This has been so slight as not to jeopardize the work, and shows that the first section of the apron, in conjunction with the Federal Point jetty, is doing good service as a deflector of the ebb currents.

"It is true that the apron alone contracts but little the area of the water-way of the inlet, but, looking to the future, we may regard it (as it was intended to be) as a substructure which may hereafter be raised to any desired height, even to the entire closure of the inlet, if funds are furnished for that purpose."

No. 23. Model of San Juan mining region. Contributed by Lieut. George M. Wheeler, Corps of Engineers.

CLASS E.

COUNTERPOISE GUN CARRIAGES AND PLATFORMS.

No. 1. Model of a counterpoise gun carriage. Contributed by Captain King, Corps of Engineers, brevet major, U. S. A.

This carriage belongs to a large class of designs, which have been presented from time to time, and the general object of which is to have the position occupied by the piece when "from battery" protected from the enemy's fire, thus enabling the men to work the guns in places where they would otherwise be useless; *e. g.*, when the position is within effective range of sharpshooters.

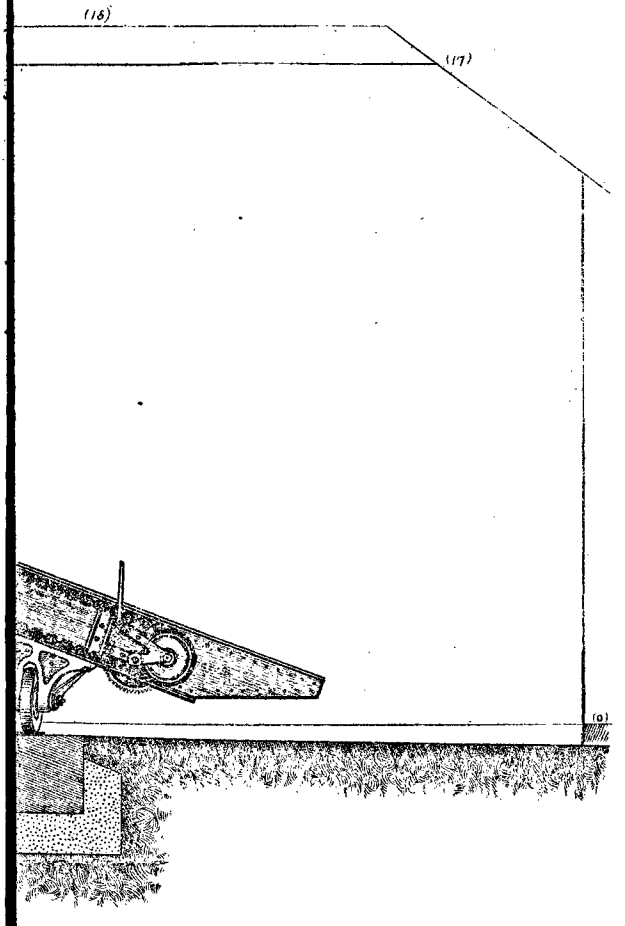
This class of designs may be arranged in several subdivisions, differing materially in the manner in which they endeavor to effect their object.

The largest subdivision and the one promising the greatest success is that called depressing gun carriages, where the gun is sheltered by being lowered behind the parapet as it moves to the rear under the action of the recoil, and of which the Moncrieff is a notable example.

To this subdivision this carriage belongs. The inventor, Capt. W. R. King, United States Engineers, sought to accomplish two distinct objects in the construction of this carriage: (1) to obtain a carriage which would, under all circumstances, be adequate to its purpose, and (2) to utilize in the construction of these carriages the material of our present ones at a minimum of expense in the modifications required.

To this end the carriages were to be made from the ordinary barbette carriages, with the following modifications:

(1.) The rear ends of the chassis rails were lowered by shortening the rear traverse forks.



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OF A

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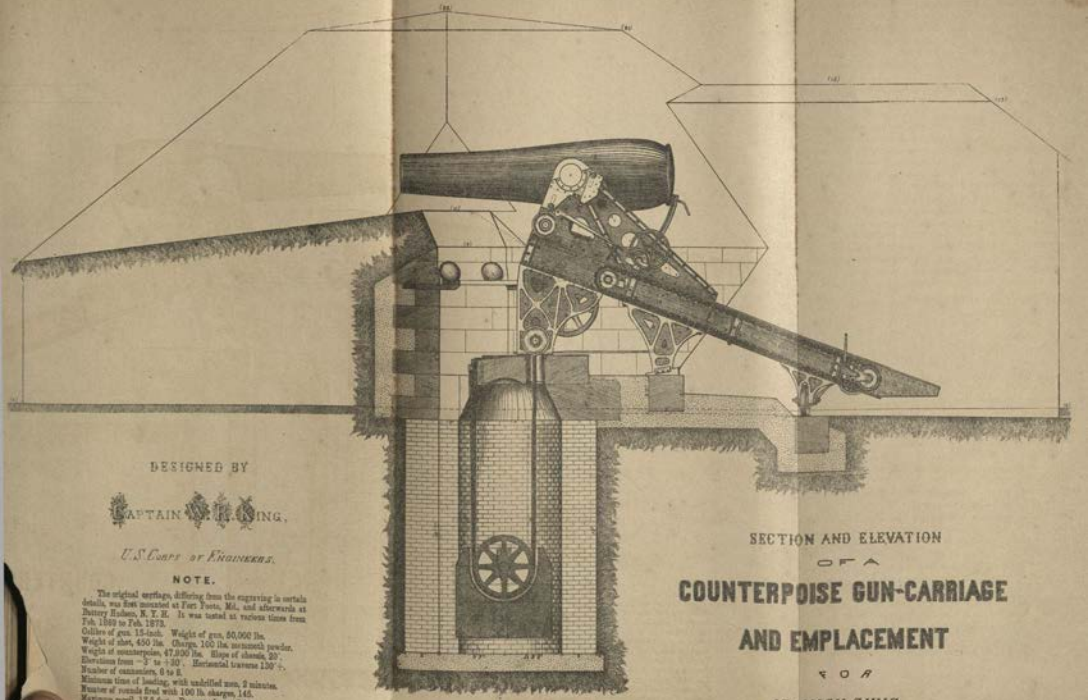

DESIGNED BY

CAPTAIN [illegible] KING,

U.S. Corps of Engineers.

NOTE.

The original carriage, differing from the engraving in certain details, was first mounted at Fort Foote, Md., and afterwards at Battery Rodman, N. Y. H. It was tested at various times from Feb. 1889 to Feb. 1873.
Calibre of gun, 15-inch. Weight of gun, 50,000 lbs.
Weight of shot, 450 lbs. Charge, 100 lbs. mammoth powder.
Weight of counterpoise, 47,000 lbs. Slope of chassis, 20°.
Elevations from −3° to +30°. Horizontal traverse 120°.
Number of commanders, 6 to 8.
Minimum time of loading, with unbuffled gun, 2 minutes.
Number of rounds fired with 100 lb. charges, 145.
Maximum recoil, 17.5 feet. Descent of gun, 6 feet.

SECTION AND ELEVATION

OF A

COUNTERPOISE GUN-CARRIAGE AND EMPLACEMENT

FOR

15-INCH GUNS.

(2.) The front ends of these rails were raised by lengthening the front support, giving to the chassis an inclination of about 18°.

(3.) A wedge-shaped piece was cut off the cheeks of the top carriage, so that its horizontal lines remained unchanged.

(4.) A pulley and wire rope for a counterpoise were introduced, the pintle being made larger and hollow for the rope to pass through it.

With these exceptions the arrangement may remain as at present, the details of loading and maneuvering being unchanged.

The carriage as thus constructed is mounted upon an ordinary platform, having a circular well 8 inches in diameter immediately beneath the pintle. In this well hangs the counterpoise, the weight of which results from the following formula: $W = \frac{w \times d}{D}$; in which W represents the weight of the counterpoise; w, that of the gun and top carriage; d, the vertical distance in feet through which the gun descends during the recoil; and D, the distance in feet through which the counterpoise rises.

The wire rope from the counterpoise runs over a pulley between the front supports of the chassis, and is fastened to the lower part of the top carriage.

When the gun is "in battery," this rope draws nearly at right angles to the chassis, gradually changing its angle as the piece runs back, until finally, before the gun stops, it draws parallel. By this means, combined with the elasticity of the counterpoise system, the shock, or very sudden motion communicated to the gun and top carriage by the explosion of the charge, is much more gradually transmitted to the counterpoise, the strain upon the rope being in fact almost constant.

The necessary elasticity of the counterpoise system is obtained by the rope of steel wire, and by making the counterpoise in sections, with disks of rubber between them. Cranks and endless chains at the sides of the chassis furnish a means of maneuvering the gun when not firing, or when the recoil or counterpoise do not complete their work.

The recoil of the gun when fired carries it down to the loading position, where it is held by friction due to its own weight.

When thrown "in gear" by turning the hand-wheels at the side of the top carriage, the weight of the gun coming upon the truck wheels, the counterpoise overcomes the rolling friction and runs the gun up to the firing position.

The gun is traversed in the ordinary manner, and the elevation is given by the same hand-wheels that run the gun up, as before described.

The original carriage, differing from the model in certain details, was first mounted at Fort Foote, Md., in 1869. This carriage was made from a 10-inch barbette carriage, which was originally intended to carry a 10-inch gun weighing about 17,000 pounds and using a maximum charge of 40 pounds of powder. On the remodeled carriage there was mounted a 15-inch gun weighing 50,000 pounds, and using a battering charge of 100 pounds of mammoth powder and a solid shot weighing 450 pounds. A counterpoise of 48,000 pounds was used.

The Board of Engineers for Fortifications, by direction of the Chief of Engineers, convened at Fort Foote in August, 1869, and after having fired four experimental shots with charges of 100 pounds and solid shot of 450 pounds, and at elevations of 30°, 15°, 0°, and −3°, respectively, submitted a report embodying the following points:

(1.) That they considered Major King's design a successful application of the principle of counterpoise; but,

(2.) The Board had some doubts as to the capability of the rope carrying the counterpoise to do the work required of it, and could not speak positively until the gun had been fired a greater number of times than in an ordinary engagement.

(3.) That some defects in details which the firing had developed, but which were entirely independent of the principle, should be remedied in future constructions.

(4.) The Board recommended a continuance of the trials.

Accordingly in May, 1871, this Board was again convened at Fort Foote, and hav-

ing fired six shots, with the same charge as before, and at elevations ranging from —3° to 30°, reported that "the carriage worked admirably within its recoil, and running into battery," except in one case, which the Board ascertained, by firing another shot, was due to the imperfect sanding of the rails.

The Board recommended that the carriage be subjected to the "severest test of actual war service," and that it be transferred from Fort Foote to some place where a greater horizontal field of fire could be obtained. These recommendations were concurred in and carried into effect.

The gun and carriage were removed to Battery Hudson, New York, and in August, 1871, a mixed Board was appointed to conduct the experiments.

In view of the doubts expressed about the strength of the rope, the attention of the Board was particularly called to this point, and they were instructed to ascertain by actual trial the time required to replace a broken rope. The strength and durability of the rope were so conclusively shown during the trials, that the Board did not deem it necessary to make the experiments contemplated in the instructions, and so reported.

Before this Board 130 rounds were fired, shot at 450 pounds and shell at 318 pounds being used, 122 rounds with 100 pounds of powder and 8 with lesser charges. These shots were fired in every possible position of the gun, and under various conditions of the rails. The last shot deserves especial mention. The charge was 100 pounds, the projectile a 450-pound shot. The elevation was 12°, making the line of fire nearly parallel to the chassis, which position is the most trying one for the counterpoise. The rails were covered with a coating of ice one-quarter inch in thickness, water having been previously poured over them.

"The gun recoiled 5 feet 2¾ inches beyond the end of the chassis, striking the ground and rebounding 2 feet 4 inches. The counter heurters were broken by the bolts being sheared off. The top carriage on its return was caught by the iron plate of the left buffer, which jamming in the rear transom broke off one bolt and slewed the carriage slightly to right on the chassis. * * * The carriage was run into battery by starting it, and slewing it to the left with three handspikes. The carriage, except the devices for checking recoil, apparentley *uninjured*." (Official Firing Record.)

The Board recommended that this carriage be referred, together with other devices which might be suggested, to a Board for competitive trial.

This Board also procured estimates as follows:

For platform and parapet	$4,672 18
For carriage complete	5,650 00

In the latter part of 1872 Generals Newton and Gillmore, in conducting some experiments for another purpose, used this carriage, firing 10 rounds (1 blank) with 100 pounds powder and 450-pound shot. Some of these rounds were very trying ones upon the carriage.

A Board, as referred to above, was convened in January, 1873, and proceeded to the examination of the various devices which were brought before them, King's carriage among the number. Before this Board four more shots were fired with service charges.

The sense of the Board is expressed in the following resolution:

"*Resolved*, That the Board, being of the opinion that the depressing gun carriage devised by Capt. W. R. King, United States Engineers, has already been sufficiently tested, and has been proved to be a good and reliable carriage for heavy guns, well adapted to certain localities, does therefore recommend that this carriage be subjected to such further trials as may be deemed necessary to determine its merits as compared with those of other carriages for heavy guns." (Report of the Board, Ord. Mem., No. 16.)

This completes the history of the test that this carriage has undergone.

One hundred and sixty-three shots are recorded, of which 142 were with service charges.

No. 2. Model of a muzzle-pivoting, counterpoise gun-sling. Contributed by Major King.

This is described by Major King as follows:

"This affair is really a *substitute* for a carriage, since it has neither chassis nor top carriage. Its more prominent parts are described as follows: The weight of the gun is borne by a wire rope, one end of which is attached to a strong rail or curved link, looped over the trunnions, and the other to a counterpoise about equal to the weight of the gun.

"It might be found desirable to work the guns in pairs, in which case the rope would connect two guns in adjoining casemates, similarly suspended.

"The rope passes over a pulley, directly over the trunnions, which has a lateral motion upon rollers which run upon a horizontal traverse rail suspended from the intrados of the casemate arch. (See side and rear elevations.) The rope then leads to a pulley directly over the throat of the embrasure, in order that the rope shall always draw at right angles to the traverse rail, and not interfere with the traversing of the gun. It then runs to the pier between the casemates, where it takes a turn around a windlass, and is then either attached directly to the counterpoise or connected to a similar system in the adjoining casemate, as before stated.

"The windlass (not shown in the drawing) is so arranged that by turning it the gun may be elevated or depressed, but an increase or diminution of the strain upon the rope could not turn the windlass. This is required, since a counterpoise for the gun when it was at rest would not be sufficient when it was swinging as a pendulum.

"To guide the muzzle of the piece and check the recoil, as well as to regulate its motion when swinging into battery, two parallel beams of wood or iron are placed over and nearly parallel with the axis of the piece, and attached at the front end to eye-bolts, which serve as a pintle, and by means of a compressor and guide-pieces, form a sliding connection with the harness or breeching of the piece.

"The harness is firmly secured to the trunnions and around the muzzle, and by tightening the nuts of the compressor the recoil may be checked at the proper point for loading. The compressor may be so arranged that it will only be necessary to tighten one nut. It will be noticed that the pintle is in a very exposed situation, but if by chance a shot strikes so near the edge of the opening as to hit the pintle, it would probably dismount the gun whether the pintle was there or in ever so well protected a situation, and it is believed this would occur with any possible form of embrasure or system of mounting guns.

"The gun may easily be traversed by train or watch tackles similar to those used in the Navy for like purposes. These will be attached to the guide pieces, and left in position when the piece is fired. The elevation of the piece will be adjusted by simply turning the windlass already referred to, immediately above the counterpoise.

"The loading will be effected in the same manner as in case of guns mounted in the ordinary way, the operation being rendered easier, however, by the steps under the muzzle of the gun. These steps answer the double purpose of loading steps, as just mentioned, and of buttresses to re-enforce the shield or front of the casemate. There will also be room, since there is a chassis to provide for, to re-enforce the piers by a strong concrete backing inclosed in a thin casing of iron which would prevent any fragments from being detached by the shock transmitted through the masonry from projectiles striking in front.

"The dotted line inclosing the piers in the plan, but not shown in elevation, shows the position which these casings might have; though if necessary they could occupy still more space in the casemates and communication arches. The sighting of the piece will be done through openings between the compressor rails.

"When the piece is fired the strain upon the rope will be at first diminished, but, as the recoil takes place, it will increase again until it becomes somewhat greater than the weight of the gun. The extent of this variation will not, however, be so

great or sudden as to cause any injury to the rope, pulleys, or other parts of the system.

"To recapitulate, the advantages sought by this system of mounting casemate guns are:

"(1.) A reduction of the embrasure-opening to an absolute minimum.

"(2.) As a result of this, and of the additional room gained in the casemate, a stronger shield and stronger fastenings.

"(3.) An increased elevation of the gun, this arrangement giving 19° elevation and 7 depression.

"(4.) 13 and 15-inch guns may be placed in 10-inch casemates.

"(5.) Cheapness, since this arrangement would probably cost less than any muzzle-pivoting carriage ever proposed, and even less than the ordinary carriage.

"(6.) Greater elasticity of the system, and consequently less concussion and less liability to jar and crack the masonry.

"(7.) Less annoyance to the cannoneers from the blast of the piece."

No. 3. Model of siege battery with balanced platforms. Designed and contributed by Capt. W. R. King, Corps of Engineers, brevet major, U. S. A.

The parapet for this battery is made about 9 feet high, revetted in the rear to give a vertical face. Behind this parapet two longitudinal ramps are constructed, starting at about 6 feet below the terreplein and approaching each other so as to meet about 4½ feet below the interior crest.

Rails are laid on these ramps, on which the carriages run up and down.

Strong frames of timber are made in the form of a right-angled triangle, so arranged that when the hypothenuse is placed on the ramp the upper side is horizontal. A sufficient number of these frames are fastened together to form a strong truck, and mounted on wheels. On the horizontal top of this truck, an ordinary siege platform is laid. A windlass is placed at the intersection of the ramps. Ropes from the two platforms are carried to this windlass and wound in opposite directions, so that the turning of the windlass by means of a large pilot wheel runs one platform up and the other down.

The carriages balance each other so that the only work to be performed at the wheel is to overcome the friction of the parts and lift the weight of one charge.

The ropes are so regulated that when one carriage is at the bottom of the ramp, or its platform on the level of the terreplein, the other platform is at the proper level for firing. This battery is intended for use on works exposed to fire at short range. In the loading position the gun and men are protected by the parapet from direct and low curved fire, as in other depressing carriages. The guns are to be loaded and fired alternately, and when not in use to be left at half height, in which position both are protected.

No. 4. Model of sea-coast mortar-battery and loading truck. Designed and contributed by Capt. W. R. King, Corps of Engineers, brevet major, U. S. A.

The advantages sought in this construction are (1) to bring the mortar as low as possible, thus diminishing the labor of loading and making its protection easier; and (2 to improve upon the present method of maneuvering, especially as regards traversing.

The carriage consists of a strong circular frame of wrought-iron, placed on a set of rollers, giving it a rotary motion about a vertical axis, and no other. To this frame are fastened two cheeks of peculiar construction. The trunnion beds have a motion up and down in the cheeks, like the cross-head of an engine. They are held in place by springs of rubber or steel, and when the mortar is fired, they move downward until the force of the recoil has been taken up in compressing the springs.

The elevation and direction are both given by a single handspike. The direction is obtained by graduations on the exterior circle of the carriage, and a fixed reference in the platform.

No. 5. Model of a counterpoise depressing gun-carriage. Designed by the late Brig. Gen. R. E. De Russy, Corps of Engineers. Contributed by the Engineer Department.

This carriage was devised about the year 1835.

The top carriage rests in front on the axle of a pair of large eccentric wheels, the rear end resting on small wheels running on curved wooden braces.

In the firing position the axle of the eccentric wheels is in its highest position, and the small wheels on the highest point of the braces. As the gun recoils, the axle runs to its lowest position, and the truck wheels to the bottom of the braces, the recoil being partly taken up by a counterpoise of metallic spokes on the side of the main wheels opposite the axle, and partly by frictional appliances.

The gun is run into battery by a windlass and chain.

It will be seen that this carriage embodies the principle which Captain Moncrieff has lately employed in the construction of his depressing carriage.

CLASS F.

MILITARY ENGINEERING.

No. 1. Models of ponton train as adopted and in use in the United States service, scale 1 to 12. Contributed by Maj. H. L. Abbot, Corps of Engineers, brevet major-general, U. S. A. Models made by First Sergeant G. B. Bensen, Battalion of Engineers.

These models comprise: (*a*), one section of the advance-guard or canvas ponton train, consisting of only one type of wagon; one loaded with a complete bay of bridge, one with trestles, and one with extra chess; (*b*), one section of reserve or wooden ponton train, consisting of two types of wagons; one loaded with a ponton, one with trestles, and one (same as advance-guard wagon) with chess; (*c*), tool wagon; and (*d*), traveling forge for use with either train.

Each wagon carries its complete service.

No. 2. Ponton train used in the United States service.

Outside the Government building, near the Army hospital are shown: (*a*) a modern and (*b*) a canvas ponton wagon, (*c*) a trestle wagon, (*d*) a chess wagon, (*e*) a tool wagon, and (*f*) a traveling forge. These were taken from a train which is stored at Willets Point, New York Harbor.

No. 3. Models of ponton bridges as adopted for the United States service, scale 1 to 12. Contributed by General Abbot. Models made by Sergeant Bensen.

(*a*), Three bays of canvas ponton bridge, and (*b*), three bays of wooden ponton bridge.

Each part shows the trestle and abutment bay.

For further information concerning the bridge equipage and its service, see "U. S. Bridge Equipage and Drill" (Engineer publications), and "Duane's History of the United States Bridge Equipage," forming Paper No. 1 of the printed papers of the "Essayons Club."

No. 4. Model of a spar bridge. Contributed by General Abbot.

This bridge is designed for use in an emergency, where a narrow stream, not fordable, is to be crossed. It needs no material but poles and lashings, and no tools but axes.

No. 5. A wicker gabion, for temporary revetment. Contributed by General Abbot.

For details of construction (drill, &c.), see "Manual of Engineering," by Capt. O. H. Ernst, Corps of Engineers.

No. 6. Iron gabion, for use where brush is not available, or for semi-permanent revetment; also useful when the soil is fine sand which sifts through the wicker gabion.

No. 7. Sap fagot, for use with either wicker or iron gabion.

No. 8. Siege and mining tools as used in the United States service. Contributor, General Abbot.

They comprise, 1 large and 2 small picks, 1 long and 1 short shovel, 1 spade, picket shovel, axes, hatchets, bill hook, gabion knife, sand scoops, pickets, tracing tape, and push pick.

No. 9. Model of a block-house. Devised by Maj. William E. Merrill, Corps of Engineers, brevet colonel, U. S. A., and used in the Department of the Cumberland for the defense of railroad bridges. Model contributed by Colonel Merrill.

Block-houses of this form were designed to be defended by musketry, and to withstand the effects of field artillery. They are octagonal in form, this shape giving a stronger fire in the direction of the diagonals than the rectangular. They have two stories, the lower being formed of a double thickness of heavy logs, and loop-holed. The upper story is smaller, of lighter construction, and is intended to afford a look-out and more comfortable quarters when the garrison is not engaged, but to be abandoned in action, the occupants retreating to the lower story. The block-house is surrounded by a ditch, from the bottom of which an embankment is run to the under side of the loop-holes. Colonel Merrill designed several other block-houses for various purposes, descriptions and drawings of which may be found in the appendix to "Van Horne's History of the Army of the Cumberland."

CLASS G.

MISCELLANEOUS.

No. 1. PUBLICATIONS OF THE ENGINEER DEPARTMENT, UNITED STATES ARMY.

[Contributed by General A. A. HUMPHREYS, Chief of Engineers.]

No. 1. Bitumen: its varieties, properties, and uses. Compiled from various sources, by Lieut. H. Wager Halleck. 8°. Washington, 1841.

No. 2. A special report on the sea-wall built in the year 1843 for the preservation of Ram Head at the northwest end of Lovell's Island. By Col. S. Thayer. 8°, Washington, 1844.

No. 3. Sustaining walls: geometrical constructions to determine their thickness under various circumstances. By Capt. D. P. Woodbury. 8°. Washington, 1854.

No. 4. Description of a system of military bridges with India-rubber pontons. Prepared for the use of the United States Army. By Capt. George W. Cullum. 8°. New York and Philadelphia, 1849.

No. 5. An analytical investigation of the resistance of piles to superincumbent pressure. By Bvt. Lieut. Col. James L. Mason. 8°. Washington, 1850.

No. 6. Report on the effect of firing with heavy ordnance from casemate embrasures, and also the effects of firing against the same embrasures with various kinds of missiles. By Bvt. Brig. Gen. Joseph G. Totten. 8°. Washington, 1857.

No. 7. Treatise on the various elements of stability in the well-proportioned arch, with numerous tables of the ultimate and actual thrust. By Capt. D. P. Woodbury. 8°. New York, 1858.

No. 8. Official report to the United States Engineer Department of the siege and reduction of Fort Pulaski, Ga., February, March, and April, 1862. By Brig. Gen. Q. A. Gillmore. 8°. New York, 1864.

No. 9. Practical treatise on limes, hydraulic cements, and mortars. By Q. A. Gillmore, A. M., brigadier-general, United States Volunteers, and major United States Corps of Engineers. 8°. 4th edition. New York, 1872.

No. 10. Longitude by lunar culminations. By Prof. W. H. C. Bartlett. 4°. Washington, 1845.

No. 11. On the use of the zenith and equal altitude telescope in the determination of the latitude. By Capt. T. J. Lee. 4°. Washington, ——

No. 12. Tables and formulæ useful in surveying, geodesy and practical astronomy, including elements for the projection of maps, and instructions for field magnetic observations. By Thos. J. Lee. 8°. Third edition revised and enlarged. Washington, 1873.

No. 13. Report upon the physics and hydraulics of the Mississippi River; upon the protection of the alluvial region against overflow; and upon the deepening of the mouths. By Capt. A. A. Humphreys and Lieut. H. L. Abbot. 4°. Philadelphia, 1861.

No. 14. Siege artillery in the campaigns against Richmond, with notes on the 15-inch gun, by Bvt. Brig. Gen. Henry L. Abbot. 8°. Washington, 1867.

No. 15. On the use of the barometer on surveys and reconnaissances. With an appendix. By R. S. Williamson, major, Corps of Engineers, brevet lieutenant-colonel, U. S. A. 4°. New York, 1868.

No. 16. Engineer and artillery operations against the defenses of Charleston Harbor in 1863; with a supplement. By Q. A. Gillmore, major of Engineers, brevet major-general, U. S. A. 8°. New York, 1868.

No. 17. Report on certain experimental and theoretical investigations relative to the quality, form, and combination of materials for defensive armor. By Bvt. Maj. W. R. King. 4°. Washington, 1870.

No. 18. Report of the geological exploration of the fortieth parallel. By Clarence King, United States geologist.

Volume III. Mining industry. By James D. Hague, with geological contributions by Clarence King. 4° and atlas. Washington, 1870.

Volume V. Botany. By Sereno Watson, aided by Prof. Daniel C. Eaton and others. 4°. Washington, 1871.

No. 19. Report on béton aggloméré or coignet-béton and the materials of which it is made. By Q. A. Gillmore, major, Corps of Engineers, brevet major-general, U. S. A. 8°. Washington, 1871.

No. 20. A report on the defenses of Washington to the Chief of Engineers, U. S. A., By Bvt. Maj. Gen. J. G. Barnard. 4°. Washington, 1871.

No. 21. Report on the fabrication of iron for defensive purposes and its uses in modern fortifications, especially in works of coast defense. By Bvt. Maj. Gen. J. G. Barnard, Bvt. Maj. Gen. H. G. Wright, and Bvt. Lieut. Col. Peter S. Michie. With a supplement. 4°. Washington, 1871.

No. 22. Report on the North Sea Canal of Holland, and on the improvement of navigation from Rotterdam to the sea. By Bvt. Maj. Gen. J. G. Barnard. 4°. Washington, 1872.

EXPLORATIONS AND SURVEYS.

History of the expedition under the command of Captains Lewis and Clarke to the sources of the Missouri, thence across the Rocky Mountains, and down the River Columbia to the Pacific Ocean. Performed during the years 1804–5–6. By order of the Government of the United States. 8°. 2 volumes, Philadelphia, 1814.

Exploratory travels through the western territories of North America, comprising a voyage from Saint Louis, on the Mississippi, to the source of that river, and a journey through the interior of Louisiana and the northeastern provinces of New Spain. Performed in the years 1805, 1806, and 1807, by order of the Government of the United States. By Zebulon Montgomery Pike, major Sixth Regiment United States Infantry. 4°. London, 1811.

Account of an expedition from Pittsburgh to the Rocky Mountains, performed in the years 1819, 1820. By order of the Hon. J. C. Calhoun, Secretary of War, under the command of Maj. S. H. Long, of the United States Topographical Engineers. Compiled from the notes of Major Long, Mr. T. Say, and other gentlemen of the party, by Edwin James, botanist and geologist to the expedition. 8°. 3 volumes.

Narrative of an expedition to the source of Saint Peter's River, Lake Winnepeek, Lake of the Woods, &c., performed in the year 1823, by order of the Hon. J. C. Calhoun, Secretary of War, under the command of Stephen H. Long, United States Topographical Engineers. Compiled from the notes of Major Long, Messrs. Say, Keating, and Colhoun, by William H. Keating, A. M., &c. 8°. 2 volumes.

Geological report of an examination made in 1834 of the elevated country between the Missouri and Red Rivers. By G. W. Featherstonhaugh, United States geologist. 8°. Washington, 1835.

Report intended to illustrate a map of the hydrographical basin of the Upper Mississippi River, made by J. N. Nicollet while in employ under the Bureau of the Corps of Topographical Engineers, 1838–1843. 8°. Washington, 1845.

Report of the exploring expedition to the Rocky Mountains in the year 1842, and to Oregon and North California in the years 1843–'44. By Bvt. Capt. J. C. Frémont. 8°. Washington, 1845.

New Mexico and California, containing:

Notes of a military reconnaissance from Fort Leavenworth in Missouri, to San Diego in California, including part of the Arkansas, Del Norte, and Gila Rivers. By Lieut. Col. W. H. Emory.

Report of Lieut. J. W. Abert of his examination of New Mexico in the years 1846–'47.

Report of Lieut. Col. P. St. George Cooke of his march from Santa Fé, New Mexico, to San Diego, Upper California.

Journal of Capt. A. R. Johnson, First Dragoons. 8°. Washington, 1848.

Report of the survey of the northern and western boundary line of the Creek country, 1849. By Bvt. Capt. L. Sitgreaves and Lieut. J. C. Woodruff, Topographical Engineers, U. S. A. 8°. Washington, 1858.

Report on the route from Fort Smith, Ark., to Santa Fé, N. Mex., made in 1849, by J. H. Simpson, lieutenant, Topographical Engineers, U. S. A. 8°. Washington, 1850.

Reports of the Secretary of War with reconnaissances of routes from San Antonio to El Paso. By Bvt. Lieut. Col. J. E. Johnston, Lieut. W. F. Smith, Lieut. F. T. Bryan, Lieut. N. H. Michler, and Capt. S. G. French, of Quartermaster's Department. Also the report of Capt. R. B. Marcy's route from Fort Smith to Santa Fé; and the report of Lieut. J. H. Simpson, of an expedition into the Navajo country; and the report of Lieut. W. H. C. Whiting's reconnaissances of the western frontier of Texas. 8°. Washington, 1850.

Exploration and survey of the valley of the Great Salt Lake of Utah, including a reconnaissance of a new route through the Rocky Mountains. By Howard Stansbury, captain, Corps of Topographical Engineers, U. S. A. 8°. Philadelphia, 1852.

Exploration of the Red River of Louisiana in the year 1852, by Randolph B. Marcy, captain, Fifth Infantry, U. S. A., assisted by George B. McClellan, brevet captain, United States Engineers. 8°. Washington, 1854.

Report of an expedition down the Zuñi and Colorado Rivers, by Capt. L. Sitgreaves, Corps Topographical Engineers. 8°. Washington, 1853.

Reports of explorations and surveys to ascertain the most practicable and economical route for a railroad from the Mississippi River to the Pacific Ocean, made under the direction of the Secretary of War, in 1853–'54–'55. 13 volumes. 4°. Washington, 1855–'60.

Report on the United States and Mexican boundary survey made under the direction of the Secretary of the Interior. By William H. Emory, major, First Cavalry, and United States commissioner. 3 volumes. 4°. Washington, 1857–'59.

Preliminary report of explorations in Nebraska and Dakota in the years 1855–'56–'57. By Lieut. G. K. Warren, Topographical Engineers, U. S. A. Reprint. 8°. Washington, 1875.

Report of a reconnaissance from Fort Riley to Bridger's Pass and return, made in 1856, by Francis T. Bryan, lieutenant, Topographical Engineers, U. S. A. 8°. Washington, 1857.

Report of a survey for an interoceanic ship-canal across the Isthmus of Darien, connecting the Atlantic and Pacific Oceans, 1857–'59. By N. Michler, lieutenant, Topographical Engineers, U. S. A. 8°. Washington, 1861.

Annual report of Capt. A. A. Humphreys, topographical Engineers, in charge of office of orations and surveys, War Department. December, 1858. 8°. Washing ton, 1869.

Report upon the Colorado River of the West, explored in 1857 and 1858 by Lieut. Joseph C. Ives. 4°. Washington, 1861.

Report of explorations across the great basin of the Territory of Utah, for a direct wagon route from Camp Floyd to Genoa, in Carson Valley, in 1859. By Capt. J. H. Simpson, Corps of Topographical Engineers, U. S. A., now colonel of Engineers, brevet brigadier-general, U. S. A. 8°. Washington, 1876.

Report of the exploring expedition from Santa Fé, N. Mex., to the junction of the Grand and Green Rivers of the Great Colorado of the West in 1859, under the command of J. N. Macomb, captain Topographical Engineers (now colonel of Engineers), with geological report by Prof. J. S. Newberry, geologist of the expedition. 4°. Washington, 1876.

Report on the construction of a military road from Fort Walla-Walla to Fort Benton. by Capt. John Mullan, U. S. A. 8°. Washington, 1863.

Report on the exploration of the Yellowstone River, by Bvt. Brig. Gen. W. F. Raynolds, with geological report of the exploration of the Yellowstone and Missouri Rivers. By Dr. F. V. Hayden, assistant, 1859–'60. 8°. Washington, 1868–'69.

Report of a reconnaissance of the Yukon River, Alaska Territory, July to September, 1869, By Capt. Charles W. Raymond. 8°. Washington, 1871.

Report of a reconnaissance of the basin of the Upper Yellowstone in 1871. By Capt. J. W. Barlow, assisted by Capt. D. P. Heap. 8°. Washington, 1872.

Report of Lieut. Gustavus C. Doane upon the so-called Yellowstone expedition of 1870. 8°. Washington, 1873.

Report on the Yellowstone expedition of 1873, by D. S. Stanley, colonel, Twenty-second Infantry, brevet major-general, U. S. A. 8°. Washington, 1874.

Report of a reconnaissance in the Ute country, made in the year 1873. By Lieut. E. H. Ruffner. Washington, 1874.

Report of a reconnaissance of the Black Hills of Dakota made in the summer of 1874. By William Ludlow, captain of Engineers, brevet lieutenant-colonel, U. S. A. 4°. Washington, 1875.

Report of a reconnaissance of the Missouri River in 1872 by Thomas P. Roberts, assistant engineer, Northern Pacific Railroad. 8°. Washington, 1875.

Report upon the reconnaissance of Northwestern Wyoming, including Yellowstone National Park, made in the summer of 1873. By William A. Jones, captain of Engineers, U. S. A. 8°. Washington, 1875.

Report of an expedition up the Yellowstone River, made in 1875, by James W. Forsyth, lieutenant-colonel and military secretary, and F. D. Grant, lieutenant-colonel and aide-de-camp, under the orders of Lieut. Gen. P. H. Sheridan. 8°. Washington, 1875.

Geographical explorations and surveys west of the one hundredth meridian, in charge of Lieut. George M. Wheeler, Corps of Engineers, viz:

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Systematic catalogue of the vertebrata of the Eocene of New Mexico collected in 1874. By E. D. Cope, A. M. 8°. Washington, 1875.

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Volume III. Geology. 4°. Washington, 1875.

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Reports of Board of Engineers on the Chesapeake and Ohio Canal. 8°. 1826.

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Report in reference to the canal to connect the Chesapeake and Ohio Canal with the city of Baltimore. By Col. J. J. Abert, 1838. Reprinted for the use of the Engineer Department, U. S. A. 4°. Washington, 1874.

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Report on the art of war in Europe in 1854, 1855, and 1856, by Maj. Richard Delafield, from his notes and observations made as a member of a "Military commission to the theater of war in Europe." 4°. Washington, 1860.

Systems of military bridges in use by the United States Army, those adopted by the great European powers, and such as are employed in British India, with directions for the preservation, destruction, and re-establishment of bridges. By Brig. Gen. George W. Cullum. 8°. New York, 1863.

Torpedoes: their invention and use, from the first application to the art of war to the present time. For the use of the officers of the Corps of Engineers. By W. R. King, captain of Engineers and brevet major, U. S. A. 8°. Washington, 1866.

Extracts from "Constructions of iron applied to fortifications, by O. Giese, captain of the royal Prussian engineers, and company commander." Translated by G. Weitzel, captain, Corps of Engineers, brevet major-general, U. S. A. 8°. Washington, 1867. (Bound in "Miscellaneous" volume.)

Reports on experimental firing with modern sea-coast artillery to determine the elements of the trajectory in both direct and ricochet firing, &c. Compiled by Bvt. Maj. W. R. King. With a supplement by Maj. C. B. Reese. 8°. Washington, 1868.

Report on blasting operations at Lime Point, Cal., in 1868. By G. H. Mendell, major of Engineers, brevet lieutenant-colonel, U. S. A. 8°. Washington, 1868. (Bound with "Miscellaneous" volume.)

Memoir on foundations in compressible soils, with experimental tests of pile driving and formula for resistance deduced therefrom. Compiled by Bvt. Maj. Gen. Richard Delafield. 8°. Washington, 1868. (Bound in "Miscellaneous" volume.)

Counterpoise gun-carriages and platforms. By Capt. W. R. King. 4°. Washington, 1869.

Report upon the removal of Blossom Rock in San Francisco Harbor, California. By R. S. Williamson, major, Corps of Engineers, brevet lieutenant-colonel, U. S. A., and W. H. Heuer, lieutenant Corps of Engineers. 4°. Washington, 1871.

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Report upon the decay and preservation of timber. By T. J. Cram, colonel, United States Corps of Engineers, brevet major-general, U. S. A. 8°. Washington, 1871. (Bound in "Miscellaneous" volume.)

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Catalogue of the mean declinations of 981 stars between twelve hours and twenty-six hours of right ascension, and thirty degrees and sixty degrees of north declination, for January 1, 1875. Prepared under the direction of Bvt. Brig. Gen. C. B. Comstock, U. S. A. By Prof. T. H. Safford. 4°. Washington, 1873.

Translation of notes accompanying drawings concerning the construction of iron lock gates, for the harbors of Weser River, Germany. By Bvt. Maj. Gen. G. Weitzel, U. S. A. 4°. Washington, 1873.

Report upon the results of firings to determine the pressure of the blast from 15-inch smooth-bore guns, made at Staten Island, New York Harbor, in 1872 and 1873. By John Newton, lieutanant-colonel of Engineers, brevet major-general, U. S. A., and Q. A. Gillmore, major of Engineers, brevet major-general, U. S. A. 8°. Washington, 1874. (Bound in "Miscellaneous" volume.)

Report of a tour of inspection of European light-house establishments, made in 1873. By Maj. George H. Elliot, Corps of Engineers, U. S. A., member and Engineer secretary of the Light-House Board. 8°. Washington, 1874.

An essay concerning important physical features exhibited in the valley of the Minnesota River, and upon their signification. By G. K. Warren, major of Engineers and brevet major-general, U. S. A. 8°. Washington, 1874. (Bound with "Miscellaneous" volume.)

Report on the compressive strength, specific gravity, and ratio of absorption of various kinds of building stone from different sections of the United States, tested at Fort Tompkins, Staten Island, New York. By Q. A. Gillmore, lieutenant-colonel, Corps of Engineers, brevet major-general, U. S. A. 8°. Washington, 1874. (Bound in "Miscellaneous" volume.)

Method of sinking cribs, devised by D. C. Houston, major of Engineers, brevet colonel, U. S. A. 4°. Washington, 1874.

Report of the Board of Commissioners on the Irrigation of the San Joaquin, Tulare, and Sacramento Valleys, of the State of California. Lieut. Col. B. S. Alexander, Corps of Engineers, U. S. A., Maj. George H. Mendell, Corps of Engineers, U. S. A., Prof. George Davidson, United States Coast Survey, commissioners. 8°. Washington, 1874.

Report on the effects of the sea water and exposure upon the iron pile shafts of the Brandywine shoal light-house. By John D. Kurtz, lieutenant-colonel of Engineers, brevet colonel, U. S. A., and Micah R. Brown, captain of Engineers. 4°. Washington, 1874.

Report of the Commission of Engineers upon the Reclamation of the Alluvial Basin of the Mississippi River. Maj. G. K. Warren, Maj. H. L. Abbot, and Capt. W. H. H. Benyaurd, Corps of Engineers, and Jackson E. Sickels and Paul O. Hébert, civil engineers, commissioners. 8°. Washington, 1875.

Report upon the applicability of movable hydraulic gates and dams to the improvement of the Ohio River. By G. Weitzel, major of Engineers, brevet major-general, U. S. A., and W. E. Merrill, major of Engineers and brevet colonel, U. S. A. 8°. Washington, 1875.

Memoranda relating to the improvement of the entrance to the Mississippi River by jetties. By A. A. Humphreys, brigadier-general and Chief of Engineers. 8°. Washington, 1875.

Report on the transportation route along the Wisconsin and Fox Rivers in the State of Wisconsin between the Mississippi River and Lake Michigan. By Gouverneur K. Warren, major of Engineers and brevet major-general, U. S. A. 8°. Washington, 1876.

Annual reports of the Chief of Engineers to the Secretary of War for the years 1866, 1867, 1868, 1869, 1870, 1871, 1872, 1873, 1874, and 1875.

Sketch showing the proposed line of water communication between the Mississippi River and the Atlantic Ocean by way of the Tennessee and Coosa Rivers and the rivers of Georgia and connecting canals. Under direction of Maj. Walter McFarland, Corps of Engineers, U. S. A. 8 sheets.

Plans of different wooden structures used in improving harbors and rivers, viz:
Plans of different wooden structures used in improving harbors on Lake Michigan.
Plan of crib work as adopted by Bvt. Col. J. B. Wheeler, major of Engineers, for piers of Lake Michigan harbors.
Plan of revetment for the Saint Mary's Falls Ship Canal.

Improvement of the Falls of the Ohio. Plans, sections, and elevations of new locks of the Louisville and Portland Canal. Under the direction of Maj. G. Weitzel, Corps of Engineers, U. S. A. 1870–'71. 8 sheets.

Sketches illustrative of reports and projects for the improvement of certain rivers and harbors.

Record of experimental firing at Fort Monroe, Va., and Fort Delaware, Del., November and December, 1868.

PHOTOGRAPHIC VIEWS.

Photographs taken in connection with the geological exploration of the fortieth parallel. Clarence King, United State geologist, in charge.
Volume I. Views in Wyoming and Northwestern Colorado.
Volume II. Views in Northern Utah and Idaho.
Volume III. Views in Nevada and Eastern California.
One set (216, two boxes) stereoscopic views.

Photographic views obtained in connection with geographical and geological explorations and surveys west of the one hundredth meridian, Lieut. George M. Wheeler, Corps of Engineers, in charge:
One volume, 50 views, seasons of 1871–'72–'73.
One volume, 25 views, seasons of 1871–'72–'73–'74.
One set (100) stereoscopic views, seasons of 1871–'72–'73.
One set (50) stereoscopic views, seasons of 1871–'72–'73–'74.

MILITARY MAPS.

Action at Drainsville, Va., December 20, 1861. United States forces commanded by Brig. Gen. E. O. C. Ord.

Atlanta, siege of, by the United States forces under command of Maj. Gen. W. T. Sherman, from the passage of Peach-Tree Creek, July 19, 1864, to the commencement of the movement upon the enemy's lines of communication south of Atlanta, August 26, 1864, from a map prepared by Capt. O. M. Poe, Corps of Engineers, U. S. A.

Army of the Cumberland, prepared to exhibit the campaigns of, under the command of Maj. Gen. George H. Thomas, compiled under the direction of Bvt. Maj. Gen. Z. B. Tower, chief engineer, Military Division of the Tennessee.

Atlanta campaign, Map I, embracing the region from the Tennessee River to the Oostanula River, and exhibiting the works of the United States and Confederate forces, with the lines of march of the United States forces under command of Maj. Gen. W. T. Sherman, 1864. Compiled in the Engineer Bureau, War Department, in 1875.

Atlanta campaign, Map III, includes the region extending from Rome, Kingston, and Cassville on the north, to include Dallas and Marietta on the south, and exhibits the works of the United States and Confederate forces, with the lines of march of the United States forces under command of Maj. Gen. W. T. Sherman in 1864. Compiled in the Engineer Bureau, War Department, in 1876.

Atlanta campaign, Map IV, illustrating the military operations of the, embracing the region from Pinne, Lost, and Kennesaw Mountains, south, to include Atlanta and its environs, exhibiting the lines of operations at Pine, Lost, and Kennesaw Mountains, at Smyrna camp ground, along the Chattahoochie River, and the investment of Atlanta, Maj. Gen. W. T. Sherman, commanding, 1864. Compiled in the Engineer Bureau, War Department, in 1874.

Armies of the Potomac and James, maps illustrating the operations of, from May 4, 1864, to April 9, 1865, including the battle-fields of the Wilderness, Spottsylvania, North Anna, Totopotomoy, Cold Harbor, siege of Petersburg and Richmond, battle-fields of Five Forks, Jetersville and Sailors Creek, High Bridge, Farmville, and Appomattox Court-House; also Harper's Ferry, Antietam, Chancellorville, Fredericksburg, and South Mountain, with index sheet. From surveys made under direction of Bvt. Brig. Gen. N. Michler and Bvt. Lieut. Col. P. S. Michie, Corps of Engineers, U. S. A.

Battle-field of Big Black River Bridge, Mississippi, May 17, 1863. Prepared under direction of Lieut. P. C. Hains, United States Engineers.

Blakely: captured by the Army of West Mississippi, April 9, 1865, showing the Confederate line of works, and the position of, and approaches by, the United States forces.

Charleston City and Harbor, South Carolina, showing the defenses of; also the works erected by the United States forces in 1863 and 1864. By Maj. Gen. Q. A. Gillmore, United States Volunteers.

Chattanooga, battle-field of; prepared under the direction of Brig. Gen. W. F. Smith, chief engineer, Military Division Mississippi, in 1864. Published, by authority of the honorable Secretary of War, in the office of the Chief of Engineers, U. S. A., in 1875.

Columbus, Ky., fortifications at; surveyed under the direction of Brig. Gen. George W. Cullum, chief of staff and Engineers, Department of the Mississippi.

Corinth and Monterey: showing the lines of intrenchments made and the routes followed by the United States forces under command of Maj. Gen. Halleck, U. S. A., in their advance upon Corinth in May, 1862. Surveyed under the direction of Col. George Thom, chief of Topographical Engineers, Department of the Mississippi.

Fort Sumter, S. C., at the time of its capture, February 18, 1865, showing the effects of the bombardment from Morris Island. By Maj. Gen. Q. A. Gillmore, commanding Department of the South.

Fort Fisher, plans and sections of: carried by assault by the United States forces, Maj. Gen. A. H. Terry commanding, January 15, 1865. Surveyed under the direction of Bvt. Brig. Gen. C. B. Comstock, A. D. C. and chief engineer.

Fort Fisher and vicinity: surveyed under the direction of Bvt. Brig. Gen. C. B. Comstock, A. D. C. and chief engineer.

Franklin, battle-field in front of. The United States forces under command of Maj. Gen. J. M. Schofield, November 30, 1864. Compiled under the direction of Col. W. E. Merrill, chief engineer, Department of the Cumberland.

Fisher's Hill and Cedar Creek, Va., battle-field of, September 22, 1864, October 19, 1864. Prepared by Bvt. Lieut. Col. G. L. Gillespie, major of Engineers, U. S. A., from surveys made under his direction by order of Lieut. Gen. P. H. Sheridan, and under the authority of the honorable the Secretary of War, and the Chief of Engineers, U. S. A., 1873.

Harper's Ferry, Va., including Maryland, Loudon, and Bolivar Heights, and portions of South and Short Mountains, with the positions of the defensive works, surveyed under the direction of Capt. N. Michler, Corps of Engineers, U. S. A., August and September, 1863.

Island No. 10 and New Madrid; also the operations of the United States forces under command of General John Pope against these positions.

Knoxville, Tenn., approaches and defenses of: showing the positions occupied by the United States and Confederate forces during the siege. Surveyed under the direction of Capt. O. M. Poe, chief engineer, Department of the Ohio, during December, January, and February, 1863-'64.

Map showing the routes followed by the Army of the Tennessee under the command of Maj. Gen. U. S. Grant, in its march from Milliken's Bend to the rear of Vicksburg, in April and May, 1863. Surveyed, compiled, and drawn under the direction of Lieut. Col. J. H. Wilson, A. I. G. and first lieutenant of Engineers.

Mobile, Confederate defenses of, occupied by the United States forces under Maj. Gen. E. R. S. Canby.

Mobile, defenses of the city of.

Marches of the United States forces under the command of Maj. Gen. W. T. Sherman, U. S. A., during the years 1863, 1864, 1865. Compiled by order of General Sherman under the direction of Bvt. Maj. W. L. B. Jenney, captain, A. D. C., U. S. A., in 1865.

Nashville, battle-fields in front of: United States forces, commanded by Maj. Gen. George H. Thomas, December 15 and 16, 1864.

Part of the operations of the Army of Virginia under command of Maj. Gen. John Pope, showing the battle-field of Cedar Mountain, August 9, 1862, positions of the troops on the night of August 27 and at sunset August 28, 1862, and the battle-field of Manassas, Va., at the close of the action on the 29th of August, 1862.

Peninsula. Campaign of the Army of the Potomac under the command of Maj. Gen. George B. McClellan, U. S. A. Map No. 1, Yorktown to Williamsburg; Map No. 2, Williamsburg to White House; Map No. 3, White House to Harrison's Landing. Prepared by command of Maj. Gen. George B. McClellan. Brig. Gen. A. A. Humphreys, chief of Topographical Engineers, Army of the Potomac.

Port Hudson and vicinity. Prepared by order of Maj. Gen. N. P. Banks under the direction of Maj. D. C. Houston and Capt. P. C. Hains, Corps of Engineers, 1864.

Plan of Fort Henry and its outworks. Drawn under the direction of Lieut. Col. J. B. McPherson, A. D. C. and captain of Engineers.

Plan of Fort Donelson and its outworks, surveyed under the direction of Lieut. Col. J. B. McPherson, A. D. C. and captain of Engineers.

Roanoke Island, battle-field of, February 8, 1862. Drawn by Lieutenant Andrews, Ninth New York Regiment.

Siege operations at Spanish Fort, Mobile Bay, by the United States forces under Major-General Canby, captured by the Army of West Mississippi on the night of April 8 and 9, 1865.

Sketch showing the relative positions of Forts Henry and Donelson, also roads connecting the two positions, drawn under the direction of Lieut. Col. J. B. McPherson, A. D. C. and captain of Engineers.

Shiloh, battle-field of, near Pittsburgh Landing, Tenn., showing the positions of the United States forces under the command of Maj. Gen. U. S. Grant, United States Volunteers, and Maj. Gen. D. C. Buell, United States Volunteers, on the 6th and 7th of April, 1862, surveyed under the direction of Col. George Thom, chief of Topographical Engineers, Department of the Mississippi.

Virginia, Central, showing Lieut. Gen. U. S. Grant's campaign and the marches of the armies under his command in 1864-'65. Engineer Bureau, War Department.

Vicksburg, siege of, by the United States forces under the command of Maj. Gen. U. S. Grant, United States Volunteers, Maj. F. E. Prime, chief Engineer; surveyed and constructed under the direction of Capt. C. B. Comstock, United States Engineers, and Lieut. Col. J. H. Wilson, A. I. G., first lieutenant Engineers.

Winchester, Va., battle-field of, September 19, 1864. Prepared by Bvt. Lieut. Col. G. L. Gillespie, major of Engineers, U. S. A., from surveys made under his directions by order of Lieut. Gen. P. H. Sheridan, and under the authority of the honorable Secretary of War, and the Chief of Engineers, U. S. A., 1873.

Waynesborough, Va., battle-field of, March 2, 1865. Prepared by Bvt. Lieut. Col. G. L. Gillespie, major of Engineers, from surveys made under his direction by order of Lieut. Gen. P. H. Sheridan, and under the authority of the honorable Secretary of War, and the Chief of Engineers, U. S. A.

Yorktown, Va., siege of. Conducted by the Army of the Potomac, under command of Maj. Gen. George B. McClellan, U. S. A., April 5 to May 3, 1862. Prepared under the direction of Brig. Gen. J. G. Barnard, chief engineer, by Lieut. H. L. Abbot, Topographical Engineers, A. D. C.

TOPOGRAPHICAL MAPS.

Arizona, Department of, sheets 1 and 3. Compiled by Lieut. J. C. Mallery, Corps of Engineers, and revised to 1875.

Augusta County, Virginia, by Jed Hotchkiss, 1865.

Black Hills, reconnaissance of, with troops under the command of Lieut. Col. G. A. Custer, Seventh Cavalry, by Capt. William Ludlow, Corps of Engineers, U. S. A., 1874. Three sheets.

Chicago Harbor and Bar, Illinois, from survey made in August and September, 1858, by Bvt. Lieut. Col. J. D. Graham, Topographical Engineers, U. S. Army.

Charleston Harbor and adjacent coast and country, South Carolina, in 1823, 1824, and 1825, by Capt. Hartman Bache, Topographical Engineers, U. S. A.

Chickasaw Nation and contiguous portions of the Indian Territory. Prepared by Lieut. E. H. Ruffner, Corps of Engineers, U. S. A., 1872.

Des Moines Rapids, with plan, profiles, and cross-sections of the canal for its improvement, by Bvt. Maj. Gen. J. H. Wilson, lieutenant-colonel Thirty-fifth Infantry, U. S. A.

Dakota Territory. Compiled under the direction of Capts. D. P. Heap and William Ludlow, Corps of Engineers, U. S. A.

Erie Harbor, Pennsylvania. Made under the direction of Bvt. Col. W. F. Raynolds, major of Engineers, U. S. A., in 1866.

Florida. Complied in the Bureau of Topographical Engineers in 1856.

Fort Dodge to Camp Supply, Indian Territory, roads from. Compiled by Lieut. E. H. Ruffner, Corps of Engineers, in 1872.

Fort Yuma, Cal., to Texas. New route for cattle droves and trains. Capt. L. C. Overman, Corps of Engineers, U. S. A.

Georgia, Northwestern, with portions of Tennessee and Alabama. Compiled in the Engineer Bureau, War Department, in 1863.

Green County, Virginia, by Jed Hotchkiss, 1866.

Indian Territory, with part of Kansas. Compiled in the Engineer Bureau, War Department, in 1866.

Indian Territory, with parts of neighboring States and Territories. Compiled by Lieut. H. Jackson, Seventh Cavalry, U. S. A., in 1869.

Indian Territory, compiled under the direction of Lieut. E. H. Ruffner, Corps of Engineers, U. S. A., in 1875.

Kansas, Texas, and the Indian Territory, with parts of the Territories of Colorado and New Mexico. Compiled in the Engineer Bureau, War Department, 1867. Corrected to 1874.

Montana Territory. Compiled under the direction of Capts. D. P. Heap and William Ludlow, Corps of Engineers, 1872 and 1875.

Madison County, Virginia, by Jed Hotchkiss, in 1866.

Military Departments of the Cumberland, the South, and the Gulf. Compiled in the Engineer Bureau, War Department, in 1863.

Military Department of the South, part of. Compiled in the Engineer Bureau, War Department, in 1865.

Military Department and Territory of Utah. Compiled in the Bureau of Topographical Engineers of the War Department in 1860.

Military Departments of Virginia, Washington, Middle, and the Susquehanna, portions of. Prepared in the Engineer Bureau, War Department, in 1863.

New Mexico. Sheet 4 of the Department of the Missouri. Compiled by Lieut. E. H. Ruffner, Corps of Engineers, in 1873.

New Mexico. Compiled by Lieut. C. C. Morrison, Sixth Cavalry, U. S. A., in 1875.

Nebraska. Sheet No. 2 of the Military Department of Platte. Compiled by Capt. W. A. Jones, Corps of Engineers, U. S. A., in 1872.

Nebraska and Wyoming, in 4 sheets, Nos. 1, 2, 3, and 4, of the Department of the Platte, by Capt. W. A. Jones, Corps of Engineers, U. S. A., in 1874.

Nebraska and Dakota, and portions of the States and Territories bordering thereon. Compiled by Bvt. Maj. Gen. G. K. Warren, major Corps of Engineers, U. S. A., in March, 1867.

Nevada, Southern and Southeastern. Reconnaissance expedition in charge of Lieut. George M. Wheeler, Corps of Engineers, U. S. A., 1869.

Patuxent and Saint Mary's Rivers, Maryland. Compiled in the Bureau of Topographical Engineers, War Department, 1857, from surveys made by Maj. J. J. Abert, Topographical Engineers, and Maj. J. Kearney, Topographical Engineers, in 1824.

Rockingham County, Virginia, by Jed Hotchkiss, in 1866.

Rappahannock County, Virginia, by Jed Hotchkiss, in 1866.

Shenandoah, Page, and Warren Counties, Virginia, by Jed Hotchkiss, 1866.

Shenandoah and Upper Potomac, including portions of Virginia and Maryland, compiled by Lieut. John R. Meigs, Corps of Engineers, U. S. A., in 1864.

Tennessee, Middle, and parts of East Tennessee and the adjoining States, compiled under the direction of Col. William E. Merrill, 1st U. S. V. V. Engineers, and captain Corps of Engineers, U. S. A., in 1865, and published in 1874.

Territory of the United States, from the Mississippi River to the Pacific Ocean, originally prepared to accompany the reports of the explorations for a Pacific railroad, by Lieut. G. K. Warren, Topographical Engineers, recompiled and redrawn under the direction of the Chief of the Corps of Engineers, 1865–'66–'67–'68.

Topographical atlas projected to illustrate geographical explorations and surveys west of the one hundredth meridian of longitude, under the command of First Lieut. George M. Wheeler, Corps of Engineers.

Ute country, Colorado, reconnaissance in the, under the direction of Lieut. E. H. Ruffner, Corps of Engineers, U. S. A., in 1873.

United States, showing the limits of the military departments and the positions of the military posts of the United States. Prepared under the direction of the Chief of the Corps of Engineers, U. S. A., in 1874. (Third edition.)

Virginia, Central, compiled in the Bureau of Topographical Engineers, War Department, in 1862.

Virginia and North Carolina, portions of, embracing Richmond and Lynchburg, Va., and Goldsborough and Salisbury, N. C. Compiled in the Engineer Bureau, War Department, in 1864.

Virginia, West, by Lieut. John R. Meigs, Corps of Engineers, U. S. A.

Virginia, Southeastern, and Fort Monroe. Compiled in the Bureau of Topographical Engineers, War Department, in 1861.

Western Territories, sheet No. 3. Compiled under the direction of Maj. G. L. Gillespie, Corps of Engineers, 1876.

Wyoming, Military Department of the Platte, sheet 3. Compiled by Capt. W. A. Jones, Corps of Engineers, U. S. A., in 1874.

Yellowstone and Missouri Rivers and their tributaries, explored by Capt. W. F. Raynolds, Topographical Engineers, and Lieut. H. E. Maynadier, Tenth Infantry, U. S. A., in 1859 and 1860.

Yellowstone Lake and the Valley of the Upper Yellowstone River. Route of Capts. J. W. Barlow and D. P. Heap, Corps of Engineers, in their reconnaissance of the region, during the summer of 1871.

Yukon River, Alaska, from Fort Yukon to the sea. Reconnaissance by Capt. Charles W. Raymond, Corps of Engineers, in July and September, 1869.

LAKE SURVEY CHARTS.

1. Agate Harbor, Lake Superior.
2. Buffalo Harbor, Lake Erie.
3. Copper Harbor, Lake Superior.
4. Chicago, City of, Illinois.
5. Detroit River, Michigan, mouth of.

6. East Neebish Rapids, River Saint Mary.
7. Eagle Harbor, Lake Superior.
8. Eagle River, Lake Superior.
9. Erie, Lake.
10. Erie, Lake, west end of.
11. Fond du Lac, west end of, Lake Superior.
12. Grand Island and approaches, Lake Superior.
13. Green Bay, head of, Lake Michigan.
14. Green Bay, north end of, Lake Michigan.
15. Green Bay, south end of, Lake Michigan.
16. Huron, Lake.
17. Huron, Lake, south end of.
18. Harbors of refuge, Lake Huron.
18. Huron Bay and Islands, Lake Superior.
20. Isle Royale, Lake Superior.
21. Kelley's and Bass Islands, Lake Erie.
22. L'Anse, including Portage Entry, &c., Lake Superior.
23. Marquette Harbor, Lake Superior.
24. Michigan, Lake, north end of.
25. Michigan, Lake, northeast end of.
26. Michigan, Lake, north end of, including Beaver Island group.
27. Maumee Bay, Lake Erie.
28. Niagara Falls.
29. Ontonagon Harbor, Lake Superior.
30. Portage Lake and River, Lake Superior.
31. Saint Marie River, No. 1.
32. Saint Marie River, No. 2.
33. Saint Lawrence River, No. 1.
34. Saint Lawrence River, No. 2.
35. Saint Lawrence River, No. 3.
36. Saint Lawrence River, No. 4.
37. Saint Clair Flats, Lake Saint Clair.
38. Saint Clair River.
39. Saint Clair Lake.
40. Straits of Mackinac.
41. Sandusky Bay, Lake Erie.
42. Saginaw Bay, Lake Huron.
43. Saginaw River, Lake Huron.
44. Superior, Lake, No. 1.
45. Superior, Lake, No. 2.
46. Superior, Lake, No. 3.
47. Tawas Harbor, Lake Huron.
48. Thunder Bay, Lake Huron.

DIAGRAMS RELATING TO FORTIFICATIONS.

Plans, sections, and elevations of a barbette battery, as proposed by the Board of Engineers for Fortifications.

Plan showing arrangement of breast-height wall and traverse proposed by the Board of Engineers for Fortifications, for securing better cover for gunners and guns.

Front pintle platforms for 15-inch and 13-inch guns, as modified August, 1870.

Center pintle platforms for 15-inch and 13-inch guns as modified August, 1870.

Wooden front pintle platform for 15-inch guns designed by General Q. A. Gillmore, with modifications based on experiments.

Wooden center pintle platform for 15-inch guns, as designed by Bvt. Maj. Gen. John Newton, Corps of Engineers.

Front pintle platforms for 15-inch guns, adapted to new ordnance carriage of 15 inches increased height.

Wooden front pintle platforms, with low traverse rail, adapted to new ordnance carriage of 15 inches increased height.

King's counterpoise gun carriage for 15-inch guns, erected at Fort Foote, Md., June, 1870.

Plan and sections of parapet and platform, with low traverse stones, for 10-inch and 8-inch smooth bore, and 100, 200, 300 pounder rifles.

Plan and sections of platforms designed for 13-inch and 10-inch mortars.

Concrete mixer employed at Fort Scammel, Me., by Lieut. Col. J. C. Duane, Corps of Engineers, with description.

Barbette traverse magazine, with bomb-proof shelter, by Board of Engineers for Fortifications.

Calculated trajectories of the 12-inch rifled gun, by Board of Engineers for Fortifications.

Elevations and details of a crane at Fort Preble, Me. Drawn under the direction of Capt. Thomas Lincoln Casey, Corps of Engineers. 3 sheets.

Fort Tompkins. Details of cranes. Drawn under direction of Maj. J. G. Barnard, Corps of Engineers.

Details of stone carriage and stone cutting shed, constructed under the direction of Maj. Thomas Lincoln Casey, Corps of Engineers, and used at Forts Scammel, Preble, and Popham.

Details of steam derrick constructed under the direction of Maj. Thomas Lincoln Casey, Corps of Engineers, and used at Forts Knox, Popham, and Gorges, Me.

No. 2. Record books of the geographical survey west of the one-hundredth meridian, being blank forms for recording all the work required of a party in the field. Contributor, Lieutenant Wheeler.

These forms give a clearness and uniformity to the field-notes, which is estimated to save more than one-half of the work of reduction.

They are astronomical (15), geodetic (2), topographical (6), meteorological (7), zoological (1), botanical (1), and mining questions (1).

No. 3. Specimens of petrified wood from Yellowstone National Park. Contributed by Capt. William A. Jones, Corps of Engineers.

The following memoir by Captain Jones fully describes the specimens:

"These specimens of petrified wood are exhibited as a remarkable occurrence in the field of mineralogy.

"To the best of my knowledge, they are the first of their kind that have been discovered. I found then in August, 1873, a few miles up the East Fork of Yellowstone River, in the mountains on the south side.

"These mountains are composed largely of volcanic conglomerate—a concrete of rounded bowlders large and small, cemented with lava. Many stumps of a fossil forest still project above the surface in this locality. Others are weathered even with the surface and the *débris* is scattered about in the vicinity. I suggest as a possible explanation of the phenomena that the ridge of mountains in which they occur was capped or largely formed by successive overflow of lava from craters or immense fissures in the mountain mass lying just to the eastward; that prior to the last overflow a forest had grown over the surface of the ridge, which was afterwards engulfed in the fluid mass of molten material; that a few of the trunks of the trees escaped being consumed by the heat, and had their woody fiber replaced by silica—which is present in large quantities in the lava—or perhaps the plastic lava left in some cases a mold more or less perfect of the slowly consumed trunk, which the silica afterwards filled in by infiltration. (See large map and trail map No. 32 of my report upon Northwestern Wyoming and Yellowstone National Park (Engineer publication), *ibid.* pp. 33, 37, 51, 184–'9).

"Specimens 1, 3, 4,5, 6, 7, 8, and 11 show that the woody fiber has been replaced; and especial attention is called to No. 4, which shows the fibrous structure of wood very distinctly, the fiber being replaced by a silky fibrous mineral resembling asbestos. Nos. 3, 4, 5, 6, and 9 indicate that the woody fiber was sometimes converted into charcoal by the heat before being replaced by the silica. Nos. 1, 2, 3, 4, and 18 were taken, in my presence, from a stump standing in the volcanic conglomerate. Particular attention is called to No. 1, which distinctly shows the bark of a tree (apparently coniferous) on the outside, and on the inside, which was hollow, a mass of amethyst crystals. No. 7 was taken at the foot of a cliff, and had evidently weathered out near the top and rolled to the foot, thus defacing its very handsome mass of crystals. Nos. 9 and 10 show the interior structure of No. 8, and formed part of the same section of a tree. Nos. 1, 3, 4, 5, 6, 8, and 9 are offered as proof that the series is silicified wood, and not from geodes. Nos. 15, 22, and 24 were taken from what appeared to be the *débris* of a trunk that had weathered down to the surface. No. 19 is evidently a knot. Nos. 12, 13, 14, 16, 17, 19, 20, 21, 22, 25, 26, and 31 were obtained in the same locality as the others and are presumably either of the same origin or else may have been formed by the infiltration of silica into accidental cavities in the lava."

No. 4. Samples of building-stones of the United States. Contributor, Lieut. Col. Q. A. Gillmore, Corps of Engineers, brevet major-general, U. S. A.

There are forty-eight specimens of granite, twenty-eight of marble, sixteen of sandstone, twelve of limestone, four of trap, two of bluestone, and one of magnesian stone. General Gillmore has, in addition to his other duties, been engaged for several years in a series of experiments upon the compressive strength and ratio of absorption of the building-stones of the United States.

His last report, containing a detailed description of the method of conducting the experiments, together with a large number of tabulated results, including the specimens here presented, may be found in the Report of Chief of Endineers for 1875, Part II.

No. 5. Field photographic outfit. Contributor, General Abbot.

It consists of two boxes closely packed and containing all the articles needful for map printing in the field.

No. 6. Publications relating to the geographical survey west of the one hundredth meridian. Contributed by Lieutenant Wheeler.

Ten volumes, as follows:

Preliminary report, 1869–'71.
Catalogue of plants, 1871–'73; and
Vertebrata of the Ecoene of New Mexico, 1874.
Progress report, 1872.
Tables of camps and distances, 1872.
Annual report, 1873–'74.
Astronomical report, 1874.
Annual report, 1875.
Report of 1875, part I, vol. IV, Paleontology.
Report of 1875, vol. III, Geology.
Report of 1875, chap. III, vol. V, Zoology.

No. 7. Cypress stump, weighing about 3 tons, taken from the channel of Cape Fear River, North Carolina, during the spring of 1875. Contributed by Colonel Craighill.

The following history and description of the removal of these stumps, consisting mainly of extracts from an "Historical sketch of the improvements of the Cape Fear

River, North Carolina," are kindly furnished by Captain Phillips, Corps of Engineers:

"In the spring of 1874 it was determined to make an attempt to remove the so-called 'Logs' or obstructions above Campbell's or 'Big' Island, about 11 miles above the New Inlet and 8 miles below the city of Wilmington.

"The main channel of the river formerly passed to the west of Campbell's Island. Between the years 1823 and 1829 a considerable amount of work was done at this part by the State government of North Carolina. One of the steps taken by the State was to shut off the channel to the west of the island, and cause all the water to pass to the east.

"This was done by means of a dike from the island to the western shore of the river, assisted by a jettee or deflector located a short distance above.

"The result of this movement was to cause the river to seek a new channel directly across the 'Logs.' It never succeeded in finding or making over 9 feet of water at low tide.

"Capt. Hartman Bache, Topographical Engineers, in a report dated November, 1827, disapproves of the plan of shutting off the channel to the westward of Campbell's Island, but states that as the dike constructed has already caused the formation of shoals above and below it, he deems it inexpedient to reopen the channel.

"If in 1827 the channel to the west of the island had so shoaled as to make it inexpedient to reopen it, it is easy to imagine its condition in 1874, or forty-seven years later. For a distance of about 3 miles the site of the old channel was occupied by an immense flat, with here and there a small pocket to indicate its old locality.

"There seemed, then, to be but one practicable way of improving this portion of the river, and that by simply cutting a channel-way through these obstructions.

"Deep water (from 15 to 18 feet) was to be found for miles both above and below the shoal, and there was every indication that by removing the obstructions not only would the channel maintain itself, but deepen under the action of the river currents.

"A large dredge-boat was accordingly chartered, fitted out with grappling apparatus, and, proceeding to the Cape Fear, was engaged at the 'Logs' from the 2d of March to the 11th of April, 1874, and again from the 17th of December, 1874, till the latter part of the following June.

"The result of this work was the completion of six cuts, aggregating 245 feet in width, across the upper portion of the shoal or the 'Logs' proper; and three cuts across the lower portion of the shoal, aggregating 125 feet in width. Twelve feet of water at ordinary low tide was thus secured across the shoal, which was an increase of 3 feet over the original depth.

"The locality it seems beyond doubt must have been at some time the site of a cypress swamp. Many cypress stumps were removed, ranging in diameter from 4 to 7 feet, together with thousands of smaller stumps, cypress knees and roots. But few logs were found, and those evidently had floated there from some other locality.

"The stumps were found projecting above the bed of the river, were perfectly sound, and were battered by the keels of vessels which had been passing over them for the last fifty years.

"Perhaps the most singular feature about these stumps was the evidence that they had been eaten off by the teredo, which, as is well known, works only in salt water. This, in connection with the fact that the water above Campbell's Island has been perfectly fresh since the early settlement of America, goes to show the great age of these stumps.

"To go back one step farther, and remark that the cypress can grow only in or in the vicinity of fresh water, and we only add one more period of unknown duration to the age of these remarkable stumps."

APPENDIX TO CATALOGUE.

I.—SPECIAL DESCRIPTION OF ARTICLES EXHIBITED

By Lieut. GEORGE M. WHEELER, *Corps of Engineers, in charge of United States Geographical Surveys west of the One hundredth Meridian.*

1. Progress map, 16 by 22 feet:

This map is designed to show the progress made, the areas occupied, astronomical stations determined, &c. It also shows the scheme of survey and mapping by rectangles, instead of political or other divisions. Each rectangle includes from 17,000 to 18,000 square miles. Each in turn can be subdivided into smaller ones of a proportionate part, as has already been done, to allow an increase of scale, and still preserve the general plan and size of the maps.

2. Triangulation map:

Showing the initial astronomical stations, measured bases, and main triangulation stations in the Colorado section of United States geographical surveys west of the one hundredth meridian.

3. Wall map:

Showing a number of the maps printed by photolithographic process, and joined together so as to represent any portion of the region surveyed that may be desired greater than that embraced in any one rectangle.

4. Wall map:

Same as above, excepting that the sheets have been produced by crayon instead of photolithographic process.

5. Wall map:

Showing graphically the geological formation of parts of the areas entered and examined by the geologists attached to the several expeditions.

6. Original atlas sheets (Nos. 50, 59, 66, 67, 75, 83, 61 (B), 69 (D), in frames. (Hand drawings.)

7. Progress map:

In frame.

8. Atlas sheet 61 B:

Colored to show natural resources.

9. Atlas:

Photolithographic sheets as published for distribution. In addition to the topographical certain other and preliminary sheets form part of the atlas, viz:

Legend sheet.—Showing names of officers and assistants engaged upon the work, projections, connections, &c.

Basin map.—Showing, by colors, the distribution of the main drainage areas west of the Mississippi River.

Progress map.—Showing, by red lines, the direction and number of the various expeditions under War Department auspices for explorations west of the Mississippi River; also showing the rectangle scheme, and, by colors, the areas surveyed during the several field seasons of the survey.

Sheet of conventional signs.—The one now in use.

Atlas (rectangle) sheets.—Nos. 49, 50, 57, 59, 61 (C), 61 B, 65, 66, 67, 69 D, 75, 76, 83; also several sheets produced by crayon process.

10. Atlas:

Geological sheets 50, one-half of (58 + 66) 59, and 67, based on the topographical maps, and showing the geological formation of a portion of the regions surveyed; also general topographical map of the region west of the Mississippi River, and map show-

ing restored outline of an ancient fresh-water lake. (For description see vol. III (Geology), chap. III, Reports upon Geographical surveys west of the one hundredth meridian.

11. Photographic copies of atlas maps on reduced scale.

12. Publications:

Preliminary report upon a reconnaissance through Southern and Southwestern Nevada, made in 1869, by First Lieut. George M. Wheeler, Corps of Engineers, U. S. A., assisted by First Lieut. D. W. Lockwood, Corps of Engineers, U. S. A., under the orders of Brig. Gen. E. O. C. Ord, brevet major-general, U. S. A., commanding Department of California; and

Preliminary report concerning explorations and surveys, principally in Nevada and Arizona, prosecuted in accordance with paragraph 2, Special Orders No. 109, War Department, March 18, 1871, and letter of instructions of March 23, 1871, from Brig. Gen. A. A. Humphreys, Chief of Engineers conducted under the immediate direction of First Lieut. George M. Wheeler, Corps of Engineers. 1871. 1 vol. 4°.

Tables containing camps, distances, lines of march, latitudes, longitudes, altitudes, &c. Explorations and surveys west of the one hundredth meridian, in Utah, Nevada, and Arizona, Field season of 1872. 1 vol. 4°.

Progress report upon geographical and geological explorations and surveys west of the one hundredth meridian in 1872 under the direction of Brig. Gen. A. A. Humphreys, Chief of Engineers, U. S. A., by First Lieut. George M. Wheeler, Corps of Engineers, in charge. 1 vol. 4°.

Report upon the determinations of the astronomical co-ordinates of the primary stastations at Cheyenne, Wyo., and Colorado Springs, Colo., made during the years 1872 and 1873. Geographical and geological explorations and surveys west of the one hundredth meridian. First Lieut. George M. Wheeler, Corps of Engineers, in charge; Dr. F. Kampf and J. H. Clark, civilian astronomical assistants. 1 vol. 4°.

Annual report upon the geographical and geological surveys and explorations west of the one hundredth meridian, in Nevada, Utah, Colorado, New Mexico, and Arizona, by George M. Wheeler, first lieutenant of Engineers, U. S. A., being Appendix EE of the Annual Report of the Chief of Engineers for 1873; and annual report upon the geographical explorations and surveys west of the one hundredth meridian, in California, Nevada, Utah, Arizona, Colorado, New Mexico, Wyoming, and Montana, by George M. Wheeler, first lieutenant of Engineers, U. S. A., being Appendix FF of the Annual Report of the Chief of Engineers for 1874. 1 vol. 8°.

Annual report upon the geographical exploration and surveys west of the one hundredth meridian, in California, Nevada, Nebraska, Utah, Arizona, Colorado, New Mexico, Wyoming, and Montana, by George M. Wheeler, first lieutenant of Engineers, U. S. A., being Appendix LL of the Annual Report of the Chief of Engineers for 1875. 1 vol. 8°.

Systematic catalogue of vertebrata of the Eocene of New Mexico collected in 1874; and catalogue of plants collected in the years 1871, 1872, and 1873, with descriptions of new species. 1 vol. 8°.

Report upon geographical and geological explorations and surveys west of the one hundredth meridian, in charge of First Lieut. George M. Wheeler, Corps of Engineers, U. S. A., under the direction of Brig. Gen. A. A. Humphreys, Chief of Engineers, U. S. A., published by authority of Hon. William W. Belknap, Secretary of War, in accordance with acts of Congress of June 23, 1874, and February 15, 1875, in six volumes. accompanied by one topographical and one geological atlas. Vol. III, Geology. 4°

Report upon geographical and geological explorations and surveys west of the one hundredth meridian, in charge of First Lieut. George M. Wheeler, Corps of Engineers U. S. A., under the direction of Brig. Gen. A. A. Humphreys, Chief of Engineers, U. S. A., published by authority of Hon. William W. Belknap, Secretary of War, in accordance with acts of Congress of June 23, 1874, and February 15, 1875, in six volumes, accompanied by one topographical and one geological atlas. Part I, vol. IV, Paleontology. 4°.

Report upon geographical and geological explorations and surveys west of the one hundredth meridian, in charge of First Lieut. George M. Wheeler, Corps of Engineers, U. S. A., under the direction of Brig. Gen. A. A. Humphreys, Chief of Engineers, U. S. A., published by authority of Hon. William W. Belknap, Secretary of War, in accordance with acts of Congress of June 23, 1874, and February 15, 1875, in six volumes, accompanied by one topographical and one geological atlas. Chapter III, vol. V, Zoology. 4°.

PHOTOGRAPHS.

13. Apache scouts in the White Mountains, Arizona.

The Sierra Blanca Mountains are the favorite hunting-grounds of the Apache Indians, for the abundance of forest, grass, and water in this region gives shelter and subsistence to deer, elk, and smaller game in great numbers. In this second view of Apache Lake are seen two scouts of the Coyotero branch of this tribe. These specimens are of the best type of the race. They are true savages in all conditions of habit and accouterment, except in their weapons, which are modern breech-loading rifles, for which they have abandoned the primitive bow and arrow. As guides and trailmen these Indians are frequently used by marching troops and scouting parties, although in that acuteness of sense which distinguishes the pathfinder they are not superior to white mountaineers of equal experience. They are treacherous also, being faithful only out of necessity, and when their actions are subject to a constant scrutiny. Physically they are tough, hardy, and well built, but are too sinewy and spare to be very handsome. In their movements they are stealthy, quick, and graceful. They are capable of great endurance, and, traveling constantly on foot, they will excel a body of horse in traversing a mountainous country. In this picture they are seen in their native dress, which consists of a buckskin jacket, a cloth around the loins, and around the forehead a handkerchief, which acts as a fillet to prevent the hair from covering the eyes.

14. Apache Lake in the White Mountains, Arizona.

About 35 miles east of Camp Apache, Arizona, in the Sierra Blanca or White Mountains, at an altitude of 10,500 feet above the sea, lies Apache Lake, the subject of the accompanying picture. This mountain pool is of no important size, being only a pistol-shot across, but is remarkable for the beauty of itself and its surroundings. It is shaded by trees of the white or Arizona oak. On its surface, in the left of the picture, a tangled web of the water-lily is floating. Lying in a valley which is a perfect basin it can have no surface outlet, but its clear and cold waters sink by some underground channel and emerge a mile or so away, feeding the north fork of the White Mountain Creek. Around the lake are masses of limestone rock, while overhead the basaltic bluffs tower to a height of 2,000 feet. In the adjacent country are groves of fine oak timber, pine forests many miles in extent, and well-watered glades covered with a luxurious growth of herbage and flowers. The lower spurs of these mountains are covered with bunch and grama grasses, and decked with blossoms of golden-rod and aster, emblematic of a mild temperature which is most favorable for the farmer, while on the heights are broad fields of timber sheltering great pastures which still subsist thousands of cattle through the summer. These conditions of beauty and fertility effectually prove that Arizona, in its entirety, is not the worthless desert that by many it has been supposed to be.

15 and 16. Black Cañon, Colorado River (2 views).

A view of Black Cañon at about its middle point, being Camp No. 8 of the Colorado River portion of the expedition of 1871. The vessel in the foreground is one of a little fleet of four boats in which the party left Camp Mohave, Arizona, on September 15 of that year. In 31 days they traveled 260 miles, passing through Painted Cañon, Black Cañon, Bowlder Cañon, Virgin Cañon, and mouth of Diamond Creek. The bed of the Colorado River is accessible by a trail from the south, and their purpose being accomplished, and with provisions exhausted, this party abandoned their boats

here, and were met by a supply train which had been ordered to this rendezvous by an overland route. This is the farthest point to which the Grand Cañon has ever been penetrated from below, the only other recorded ascent being that of a company of white men from Las Vegas Springs, Nev., whose names are inscribed on the walls of the stream about 10 miles above its mouth. The impossibility of easy navigation on this river was fully demonstrated by the perils and fatigues encountered on this journey and by the necessity of frequent portages of a most difficult character, which in this ascent were numerous and laborious, rendering the trip especially arduous and hazardous.

17. Alpine Lake in the Sierras, California.

To the westward from Camp Independence, California, the Sierra Nevada peaks stand out in bold and ragged outline, showing in the late summer, even, the spots of snow nestling in the northern and northeastern ravines leading out from the main summits. The view shows a lake, Alpine in its character, being one of the lowest of the terrace, and located, approximately, at 9,000 feet above sea-level. In the background is seen banks of snow, the extent of which is mostly veiled, and at the foot of each in turn one of these crystal reservoirs may be found. The grandeur of the rugged and exposed rock formation relieved by the frequent groves of tall pines, with lakelets often in their midst, add to a scene of natural beauty and solitude well worthy an artist's study or the traveler's admiration.

18. Cañon de Chelle, New Mexico.

Camp Beauty, Cañon de Chelle, New Mexico. Leaving Old Fort Defiance, the train for 35 miles traverses a dry and desert plateau, and then abruptly descends into this cañon, which, from the grandeur of its walls, and the green growth of vegetation on its fertile bottom, is of unrivaled beauty. This narrow gorge about one-fourth of a mile in width, is the principal home of the Navajo Indians, whose squaws cultivate the alluvial soil, raising corn, melons, peaches, and vegetables. From this secure fold their numerous flocks of sheep are driven out upon the neighboring plains to graze, returning at times for water and shelter. The walls are of sandstone, almost or quite vertical, 12,000 feet in height, of a vermilion color, blending into a dark brown, whose effect is very beautiful in the sunshine. The three shafts of rock upon the right are 1,000 feet high, standing in an isolated group in the center of the cañon. The columnar formation is also represented in the valley by the "Explorer's Column," a pillar, of equal altitude with those, which is remarkable for its regular formation and narrow base. At Camp Beauty, where tents are seen in the foreground on the left, five lateral cañons branch in all directions from the main gorge, making this the center of a star of six rays.

The word *chelle* is pronounced as if spelled *chay-e*.

19. Section of Zuñi Pueblo, New Mexico.

A view of the ancient pueblo (or town) of Zuñi, N. Mex. There are about twenty tribes of these town-builders scattered throughout the Territory, clustered in towns; hence their general name, Pueblo Indians. They are peaceful and hospitable, supporting themselves by cultivation of the soil and raising stock. They love to dwell upon the past glories of their race, and are bitter upon the people that reduced them. The pueblo of Zuñi is of great interest; the town incloses a quadrangular area, in which stands the ruins of a church built under direction of the Jesuit missionaries. All the buildings are of "adobe," and the whole town covers not much, if any, more space than the Patent Office building at Washington. Their houses are of irregular shape, piled up together, and from one to six stories in height. The "front door" is usually on top of the house, and reached by ladders, which, when drawn up, left the people a fortification against their predatory neighbors in olden days of tribal warfare. Here live about 1,600 people (including 14 Albinos), submitting without reserve to the unwritten laws of their race as interpreted by their chosen officials. Indeed, their form of government and obedience to authority would not compare unfavorably with

some modern centers of civilization. When their city was first discovered, three hundred years ago, they were a rich, prosperous, proud, and largely civilized people. They worship the sun, and believe in the second coming of the prophet Montezuma upon the back of an eagle. Hence, this bird is held sacred, and numbers are seen about the town, tamed and carefully provided for.

20. Shoshone Falls, Snake River, Idaho.

This picture affords a good view of the numerous bowlder islands which are scattered in the river above Shoshone Falls. They are twenty or thirty in number, and are separated by as many rapids and cascades, the most important of which are Lace Falls. These diminutive isles are clothed with moss and cedar trees, whose deep green is in vivid and pleasing contrast with the white foam of the fretting and dashing water. Apparently these are the remains of a wall of rock which once dammed the river here and restrained it a moment before its final leap. Near the center of the stream is Cave Island, a large rock, which is penetrated by an archway of entrance 25 feet high, forming a Titanic grotto whose mysteries have never yet been explored. The Shoshone Falls are but one of three cascades which occur in immediate succession in the descent of Snake River. Three miles above are the Little Falls, 110 feet high, and a short distance below are the Salmon Falls, 30 feet high. The latter mark the upper limit of possible navigation on the Snake River.

21. View in Conejos Valley, Colorado.

Looking up Conejos River from a point 4 miles above Beaver Lake. Here, also, the valley is populous with beavers, and, as far as the eye can reach, there are evidences of their work, which has been progressing for ages. In former times this river was a narrow, compact stream, following a direct channel, but, being dammed at various points, the drift-wood was retained, the sediment was deposited, and all of the float of the freshet was collected, forming a succession of marshy terraces of new earth along the course of the current. Through these the river now runs sluggishly, diverging into many small channels and bayous, and embracing many islands of swamp. In this alluvial earth are the tunnels and huts of the beavers, which have undermined the surface until it is too weak to sustain the weight of men who attempt to ride over it, and hence the transit of one of these beaver lands is accompanied with great labor and difficulty.

22. "Lost" Lakes, divide of Rio Grande and San Juan Rivers.

The Lost Lakes lie in a secluded spot at the head of the Conejos Cañon at an approximate height of 10,000 feet above the sea. Crossing the summit between the Conejos and Alamosa Rivers is a trail which passes very near this lacustrine group, but on account of their hidden position affords but a very short glimpse of them. Hence their name "Lost" Lakes. They are feeders of the Conejos River, which flows into the Rio Grande. They are of considerable size, the one in the foreground being three-fourths of a mile in length. Around them, and upon the neighboring hills, are dense forests of the Douglas pine or spruce and thickets of aspen. These woods are inhabited by bears, deer, mountain sheep, turkeys, ducks, and other game in great numbers, while farther down the stream an abundance of trout is found. The view before us is characteristic of the beauty of the mountain scenery of Colorado. It represents a portion of the San Juan Range, which is here the divide between the Atlantic and Pacific Oceans, and the backbone of the continent. On the distant peaks there are patches of snow yet remaining; these may be considered perennial, as the photograph was taken in the last days of summer.

23. Beaver Lake, Conejos Cañon, Colorado.

Beaver Lake, the subject of this picture, is an instance of the remarkable ingenuity displayed by the beaver in the preparation of its home. This artificial pond occupies a cove-like valley, which is bounded on one side, as is seen in the photograph, by a low promontory of earth, on the farther side of which the stream comes down, and hurries past the mouth of this nook in a series of rapids. At this point the beavers

selected a site for their dam, and, building it, they drove the backwater into this basin, and thus was formed a sheltered and untroubled pool for their aquatic operations and abode. Beaver Lake is nearly a half mile in width. The waters which feed it come directly from the high mountains, and are marvelously clear, as, for illustration, notice the reflection of the distant pine tree from its surface. The lake lies at an altitude of 9,000 feet above the sea, at a distance of 20 miles from the mouth of the Conejos Cañon, one of the most beautiful and inviting valleys to be found in the mountains of Colorado. For other views of this cañon see the following three photographs in succession.

24. Grand Cañon of the Colorado River.

The Kanab Cañon, after running due south for nearly a hundred miles, joins the Colorado at about the middle point of the Grand Cañon proper. Standing at the mouth of the Kanab and looking eastward up the Colorado, the cañon is seen in all the majesty of its grandest type. Above the river-bed the boundary walls rise a mile or more in height, sometimes abrupt an overhanging, again receding in benches of terraces, which are gigantic stairs climbing to the surrounding plateaus. Successive sheets of marble, granite, slate, limestone, and sandstone, whose courses, of a thousand feet in thickness, are distorted by folds and broken by faults, crop out along the ledges, and stripe them with all the hues of red, black, brown, and gray. The edge of the adjacent mesa or table-land is ragged with the numerous lateral washes or gulches, whose channels wind through dark recesses which are somber with the shadows of the impending cornices of stone. At the foot of the walls lie slopes of variegated and fragmentary rock, which the winter frosts have chipped from the cliffs above. Through this black abyss the river runs like a silver thread, so far in the depths that the roaring of its cataracts is lost to the listener who stands above. In the early ages of geology, however, this canal was more shallow than now, and the river washed these bowlders which are seen in the front of the picture, rounding them into their present shape.

5. Mountain Park, Conejos Cañon, Colorado.

The valley of the Conejos varies in width from one to three miles. It is almost inaccessible except by way of its mouth, being bounded on either side by an escarpment of precipitous cliffs 2,000 feet above the stream, from whose base the foot hills slope with an even and gentle grade. In all of our unoccupied territory there is no spot which offers greater advantages to the settler than this. Although it is at too great an elevation for the production of ordinary crops, yet as a grazing country it is unrivaled, and is capable of giving subsistence to thousands of cattle. It is a broad area of pasture, upon which the grass grows deep in the summer, and the snows are light in winter. Hitherto, the settler has been deterred from entering this promising district by fear of the Ute Indians, from whose power it is now reclaimed, and when visited, in 1874, it did not possess any permanent inhabitants, and was used only by the Mexicans of the Rio Grande, who were in the custom of driving their herds thither for the summer season.

26. Headlands of the Colorado River, mouth of Paria Creek, Colorado.

The lines of cliffs, determined by the occurrence of harder and more massive strata, are modified not only by the intersecting faults, which have great local effect upon the rate and manner of denudation, but by changes in the constitution of the beds which give rise to them.

At the mouth of Paria Creek the Colorado leaves the sandstones of the trias through which it has meandered for many miles in a narrow cañon, emerges for a short space into full sunlight, while it crosses the marls at the base of that formation, and then begins its descent into the carboniferous and underlying rocks, which wall it in through Marble and Grand Cañons. In these gorges the river has no flood-plain. It is a well recognized fact in the natural history of rivers that their first work of erosion, where they have rapid fall, is upon their beds, and that it is only when they have so far reduced their grades as to greatly diminish their transporting and cutting

power that they begin wearing their banks and widening their channels, so as to render flood-plains possible.

27. Album of 50 selected landscape views taken in the years 1871, 1872, 1873, and 1874.
28. Album of 25 selected landscape views taken in the years 1871, 1872, 1873, and 1874.
29. Twenty-five selected landscape views taken in the years 1871, 1872, 1873, and 1874, for display in graphoscope.
30. One hundred and forty-four (2 sets of 72 each) selected stereoscopic views taken in the years 1871, 1872, 1873, and 1874, in revolving stereoscope.

One hundred selected stereoscopic views taken in the years 1871, 1872, 1873, and 1874, in box.

WATER-COLOR DRAWINGS.

31. Cooley's Park, near Camp Apache, Arizona.

It is only within the last few years that the whites, except in large bodies, have been able to enter the Sierra Blanca region, on account of the hostile Apaches who were at home there. In the early part of the year 1873 they were finally subjugated by General Crook, in a continuous war of several years. After their conquest they were put under discipline upon different reservations, one of which is exhibited in the accompanying picture. There, through the agency of General Crook, whose excellent policy still continues in force, they have been instructed in the various arts of peaceful self-support, including the care of cattle and the cultivation of the soil, raising crops of corn, beans, potatoes, &c. Up to the present date, however, the fruits of their labors have not been sufficient for their sustenance, and they have been dependent on the Government for supplies of food. The head farmer of the White Mountain Reservation is named Cooley, a white man, whose ranch and park are shown in the picture, and who has lived with this tribe for many years.

32. Cachina, or Rain Dance, Zuñi Indians, New Mexico.

In times of great drought and during festivals the "cacique" orders the celebration of the cachina, a sacred dance. The following is a description by an eye-witness:

"Some twenty-seven persons were engaged in the ceremony. When first seen the participants were standing in a line, their faces toward the sun, and were gayly dressed, as will be evident from the following description:

"No. 1 (figures to the left) represents a dancer; costume, light-blue mask with horse-hair beard attached; necklace of a skein of black woolen yarn and beads; wreath of hemlock as a waistband; short white skirt, with fancy border, held at the waist by a green and black sash, to which was attached a bunch of long white strings hanging to the ground along the left side; a land-turtle shell pendant from the left garter below the knee, containing pebbles, which served a purpose similar to the castanet of the Spanish dancer; hemlock around the ankles, yellow eagle-feathers in the hair, and a fox-skin suspended from the waistband completed the make-up.

"No. 2 (middle figure) represents the captain, or leader. Yellow eagle-plumes in the hair, blue tunic, white under-garment, with fancy embroidered side-piece inserted, and blue woolen knitted leggings; in one hand a staff was carried, the other holding an earthen vessel containing flowers.

"No. 3 (figure to the right) represents a female dancer (character taken by male); costume, a serape with black border interwoven with various colors, a blue gown, and a wig made of rabbit hair. The ornaments were the same as those worn by No. 1.

"The male dancers stand in a line, the females facing them and chanting a low, solemn strain, keeping time with the right foot. In the intervals between the songs the leader scatters flour to the four winds to appease the anger of the Divine Being and induce him to send water from heaven.

"It may be a fact of importance to the superstitious to know that it did rain that evening, and most heavily, the storm lasting several hours."

33. Navajo Indians at home, near Old Fort Defiance, New Mexico.

The Navajoes at home, near old Fort Defiance, an abandoned military post, where their agency is now situated. They are an intelligent and fierce people by nature, and

were a warlike and predatory nation until subdued by the United States troops in 1859-'60. They are celebrated for their wealth in the varieties of stock, and said to possess greater numbers than all of the other wild tribes of New Mexico combined. Since their subjugation they have made good progress towards civilization, and are now cultivating the soil and raising enough of grain and vegetables to satisfy their own needs. In the picture will be seen, as a specimen of their husbandry, ears of corn, suspended from the tree upon the right. The framework suspended by raw-hide thongs is their native loom, at which the squaw with the necklace of beads is working upon the unfinished blanket. The Navajo blankets, woven by the women of the tribe, are famous the world over for their excellent quality and close texture, which makes them impervious to water. One of them, with black and white stripes, may be seen upon the person of the "brave" who sits on the right of the group.

34. Cactus Grove (Cereus giganteus), S. Arizona.

The drawing represents a number of individuals of the *cereus giganteus*, or giant cactus, the largest known variety. Its tall columns often extend to an altitude of 45 to 60 feet, with few branches, and these somewhat cylindrical, like the parent stalk. The trunk at its thick part often attains a diameter of 2 feet, with a dark-green rib, covered with clusters of spines. During the infancy of its growth it is usually protected by overhanging shrubs, while at stages of maturity it enjoys a prominent place in the horizon of the desert valleys usually of little profile, where it is found in large numbers and extending over distances ranging from 5 to 50 miles. It bears an insipid and sweet fruit, with a pulp comparable in consistency with the ordinary fresh fig. In cases of emergency this fruit has been used as an article of food by travelers, and also by small mammals, birds, and Indians. It often proves an important article of food because of its saccharine and aqueous qualities.

35. Stone Arrow-heads (natural size) from New Mexico.

The arrow and spear heads are of the usual style found among the ruins of this region, and are the work of a race long extinct. Their manufacture has almost become one of the lost arts, and by such Indians as still cling to the primitive bow these are sought for and still prized to tip their arrows.

36. Stone Spear-heads (natural size) from New Mexico.

Same as above.

37. Stone Hatchets (natural size) from New Mexico.

In fashioning the stone into the rude semblance of axes considerable skill is shown and the fine polish marks the care taken with these tools. Their use was probably very limited, to cutting the softer kinds of woods and working on hides. The specimens are unusually fine on account of the great beauty of the stones.

38. Water Olla (one-third size) from Zuñi pueblo, New Mexico.

This is a fine representative of the pottery in use among the modern Pueblo Indians. It is of the finer grade, the chief use of which is to carry water and as a receptacle for the various kinds of foods. Like most of their own manufacture, this specimen is profusely ornamented, and the designs well illustrate the degree of skill attained by the native artists.

39. Record Books.

(1.) Comparison of chronometers. (2.) Observations for time. (3.) Observations for latitudes. (4.) Star catalogue. (5.) Star places. (6.) Instrumental and clock corrections. (7.) Level errors. (8.) Wire intervals. (9.) Field journal. (10.) Summary of latitude and longitude computations. (11.) Time by single altitudes. (12.) Time by equal altitudes. (13.) Latitude by polaris. (14.) Latitude by circum-meridian altitudes. (15.) Computation of distances. (16.) Geodetic co-ordinates. (17.) Triangulation observations. (18.) Mountain stations. (19.) Topographical meanders. (20.) Topographical note-book. (21.) Topographical note-book. (22.) Observations and computations for magnetic dip. (23.) Observations for magnetic declinations. (24.)

Observations and computations for horizontal intensity. (25.) Computations of latitudes and departures. (26.) Triangulation and topographical stations. (27.) Sextant astronomical observations. (28.) Logarithm, traverse, and altitude tables. (29.) Meteorological observations. (30.) Aneroid readings. (31.) Aneroid and odometer readings. (32.) Barometric hypsometry computations. (33.) Aneroid profile computions. (34.) Transcript of field meteorological observations. (35.) Meteorological instructions. (36.) Botanical note-book. (37.) Natural history collections. (38.) Mining questions.

The principal field record books are those for time and latitude observations, and for sextant astronomical observations. Blanks for the noting of chronometers and for recording signals are also employed. In geodetic and topographical work, triangulation, mountain station, and meander note-books are the most important.

In the meteorological work, or that part of it bearing upon altitudes from barometric observations, three books are employed, from which transcripts are taken and forwarded to the office for computation, the third one including also observations made upon the odometer when that instrument is employed in making measurements of roads, trails, or lines of drainage. The other two books are used for noting observations made upon cistern and aneroid barometers, psychrometers, and maximum and minimum thermometers.

Zoological and botanical forms are used for field notations of the name, locality, and circumstances surrounding the collection of the various objects. The other blank forms are those used in geodetic, topographical, magnetic, and altitude computations in the office, and are those found to be most practical for the speedy reduction of field observations.

INSTRUMENTS.

40. Astronomical clock. Makers, Howard & Co., Boston.

Peculiarity of clock in pendulum bobs: (1.) Mercurial pendulum, with cylindrical openings to allow free access of air, increasing surface to obtain uniform temperature of mercury. (2.) Metallic pendulum, compensated by combination of metals.

Clock has both make and break circuit attachments, and is used at main astronomical receiving stations.

41. Break circuit sidereal chronometers. Makers, Negus & Bro.

Used at main astronomical stations.

42. Large meridian instrument. Maker, Wurdeman.

This instrument combines advantages of zenith telescope with those of transit instrument. It is used at main astronomical stations for both latitude and longitude observations. In connection with it are used the Harkness chronograph, made by Clark & Sons, of Cambridge, Mass., or chronograph of some form, and the telegraph instruments. Switch board by Tillotson.

43. Triangulation and azimuth instrument. Made by Buff & Berger, Boston.

It has 11 inch focal distance, 1½ inch aperture, telescope with eye pieces of power 30 and 40; 8 inch 10 second horizontal circle, 5 inch 20 second vertical circle, with two sets of standards; one set 3 inches in length, permanently attached to vernier plate for use of the instrument as purely triangulation instrument; the other set to be attached to raise the instrument into an astronomical transit for azimuth observations.

44. Topographer's transit. Makers, Young & Son, Philadelphia.

This is a very light instrument, with long needle and strong telescope, used on traverse lines and for three-point locations. It is the one used in meandering of roads and streams, and filling in topography fixed by bearings to triangulation stations located by large instrument.

45. Standard rod.

Sixty-inch steel rod, used as standard in measuring base apparatus, furnished by the United States Coast Survey.

46. Personal equation instrument. Made by Edward Kahler, of Washington, D. C., after design of Dr. F. Kampf.

Used at main astronomical stations for determining personal equation of observers. Consists of clock-work for passing with uniform motion a point of light over a diaphragm, time of transit being noted automatically as well as by observer, personal equation thus arrived at arranged to join stars of different rates of apparent motions.

47. Dip circle. Made by Casella, of London.

Used at main astronomical stations for determining magnetic declination.

48. Aneroid barometer. Casella pattern.

Used on traverse line for running of profiles, checked by comparison with cistern barometer every three hours. By a movable scale, scale of feet can be set to cistern correction each morning.

49. Pocket thermometer. Maker, Green, of New York.

Used at all stations where aneroid is read.

50. Hygrometers. Maker, Green, of New York.

Used at all stations where cistern barometer is read; improved form of mounting thermometers on wooden base, from specifications by Lieutenant Marshall, Corps of Engineers.

51. Maximum and minimum thermometer. Maker, Green, New York.

Used at camps and at main astronomical stations.

52. Implement box. Maker, Green.

Used for cleaning and filling barometers when necessary in the field. Changes from old form, from specifications by Lieutenant Marshall.

53. Supported tube, cistern barometer. Maker, Green; Lieutenant Marshall pattern.

Used at all camps, triangulation and topographical stations, permanent divides, important river crossings, and astronomical stations. Peculiar in construction, in that the tube is supported by gypsum so as to make it more possible to carry it over long distances without breaking.

54. Model of San Juan Mining Region.

This model shows in relief an area of 11,000 square miles, including a portion of the mountainous section of Southwestern Colorado, embracing the regions of the headwaters of the Rio Grande, Gunnison, Animas, and Uncompahgre Rivers, the lowest altitude being 7,000 feet and the highest 14,419 above sea-level. A portion of the divide between the waters of the Atlantic and Pacific Oceans crosses the southeast one-quarter from northeast to southeast. The region has become well known of late years because of discoveries of rich mines of gold and silver. The model has been constructed from the contour map of the San Juan mining region (61 C, sub.), numerous sketches and photographs furnished by the office of United States Geographical Surveys west of the one hundredth meridian. The heights are given in feet above sea-level. The horizontal scale is one inch to one mile, with a vertical scale three times enlarged.

Boundaries.—Latitude, 37°.42, 38°.07. Longitude, 107°.15, 107°.57.

II.—An Account of the Commencement of the United States Lake Survey.

By Col. J. N. Macomb, Corps of Engineers.

About the year 1840, Capt. W. G. Williams, of the Corps of Topographical Engineers, U. S. A., then in charge of the work of improving the harbor of Buffalo, and of most of the other harbors on our side of Lake Erie, was directed to commence the survey of the lakes.

At that time there was an inadequate supply of instruments, and boats, and equi-

page in general. It is therefore not surprising that but little progress was made in the first few years after the work was authorized by Congress. About the time above named I was a first lieutenant of Topographical Engineers and was ordered by Colonel Abert, the chief of the corps, to make a hydrographic survey of the Detroit River. I was assisted in this work by Lieut. W. H. Warner, and we sert in our maps of the Detroit in summer of 1842. We were then directed to report to Capt. W. G. Williams, with the understanding on the part of Col. J. J. Abert, our chief, that we should be employed upon a hydrographic survey of the "Flats of the Saint Clair."

Our report on this survey was made through Captain Williams, and upon it was based the first improvement of the "Saint Clair Flats," after the lapse of some twelve years. Just fourteen years after making this survey I had the pleasure of revisiting the ground and of restoring some of my signal stations of 1842, by the use of which a resurvey of the locality was made in much more minute detail than the first.

In 1845 Lieutenant-Colonel Kearney was placed in charge of the survey, and it was as his senior assistant that I organized the work upon the basis which gave the first useful results in the shape of charts for the lake navigation.

I served in the capacity of senior assistant, or executive officer, to Colonel Kearney until April, 1851, when I was directed to relieve Colonel Kearney, and I then remained in charge of the work until 1856.

During these last eleven years the appropriations for the work seldom exceeded $25,000 a year. In 1843 a small iron steamer was built for the work; it was to be propelled by the "submerged horizontal tub wheel," an invention of Capt. W. W. Hunter, of the U. S. N. This mode of propulsion turned out, in this case, to be a perfect failure, and the boat called the "Surveyor" was never of any use until she was thrown ashore in the great gale, October, 1844, and whilst high and dry had her machinery reset and her "tub wheels" replaced by paddle wheels of the ordinary form. Since 1845 she has rendered excellent service.

In 1856 Colonel Kearney was directed to relieve me, and I turned over the work to him in the fall of 1856. Capt. G. G. Meade, of the Corps of Topographical Engineers, was the senior assistant to Colonel Kearney. He pushed the work forward rapidly, and was soon placed at the head of it by orders from Washington directing him to relieve Colonel Kearney. In the last month of my service upon the work I received a fine iron steamer, which had been built for the survey by Messrs. Merrick & Sons, of Philadelphia. I named this boat the Search. When I gave up the survey there were two good iron steamers, a number of barges (generally for six oars), a fine assortment of instruments and camp equipage.

About that time the appropriations were much more liberal, so that my successor was enabled to expand the work, and to produce results with much greater rapidity.

In 1861 Captain Meade was relieved by Col. James Duncan Graham, and joined the Army of the Potomac in the field, and soon came to be its commanding general and a major-general in the United States Army.

Colonel Graham was relieved by Lieut. Col. W. F. Raynolds, in April, 1864, and in 1870 Maj. C.B. Comstock, of the Corps of Engineers, relieved Colonel Raynolds, and still remains in charge of this great and highly interesting work.

I regret that I did not fall in with you during my brief visit to the Centennial in September, as I could have given you more information than I find it convenient to write. I hope I may have the pleasure of meeting you in the course of our duties.

I should like very much to see your paper on the subject of the Lake Survey, and if I can add anything to it, or in any way improve it, I shall be glad to do it.

REPORT

ON THE

EXHIBITION IN ITS RELATIONS TO THE ENGINEER SERVICE.

WASHINGTON, D. C., *December* 15, 1876.

COLONEL: In obedience to your letter of May 26, 1876, asking for a report on the International Exhibition in its relations to my branch of the service, I have the honor to submit the following:

Owing to the limited time which I could spare from the administration of the engineer section, the frequent difficulties and delays in collecting information, and the numberless interruptions incident to the Exhibition, the report is not so complete as I should wish it, but I believe that no important subject has been omitted. Capt. Jas. C. Post and Lieut. E. H. Ruffner, Corps of Engineers, U. S. A., were detailed to assist me in the preparation of the report. The former prepared that portion of it relating to Military Engineering, and the latter wrote the articles on the New Port of Commerce at Trieste, and on the Suez Canal. I am indebted to Col. H. W. Benham, Corps of Engineers, brevet major-general, U. S. A., for a report on the Laying of Ponton Bridges, and for a description of his Picket Shovel; to Col. J. H. Simpson, Corps of Engineers, for a history of the Improvement of the Mississippi River; and to Lieut. Col. Q. A. Gillmore, Corps of Engineers, brevet major-general U. S. A., for a valuable report on the cements shown at the Exhibition. General Gillmore, being one of the group of judges on this subject, had special facilities for obtaining information concerning it.

The plan of construction of the report is as follows:

Engineering is divided into civil and military. Civil engineering is subdivided into engineering works and mechanical appliances, the former being described under the head of the nation in which they were constructed, the latter under the head of the class to which they belong.

So far as possible the same alphabetical order has been maintained in the body of the report as in the index.

Very respectfully, your obedient servant,

D. P. HEAP,
Captain of Engineers,
In charge of Engineer Section, War Department Exhibit.

Col. S. C. LYFORD,
Representative of War Department, Washington.

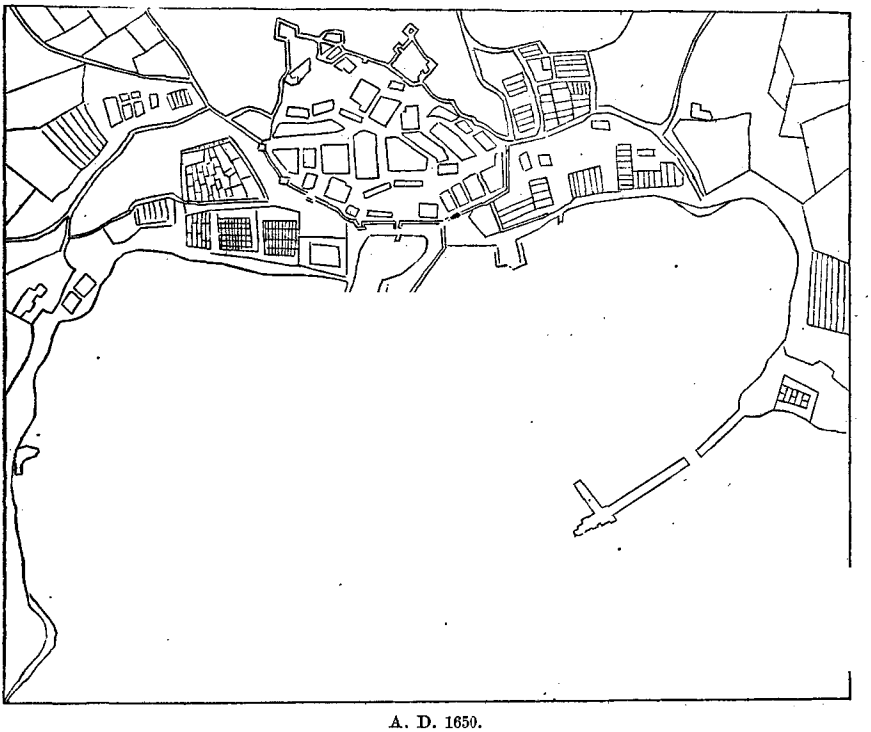
CIVIL ENGINEERING.

I.—ENGINEERING WORKS.

THE NEW PORT OF COMMERCE AT TRIESTE.

There is exhibited in the Austro-Hungary section of the main building two colored wall maps giving plans and sections of the work now in progress at this harbor; and there is also a volume of drawings of the same giving full details of the plan adopted.

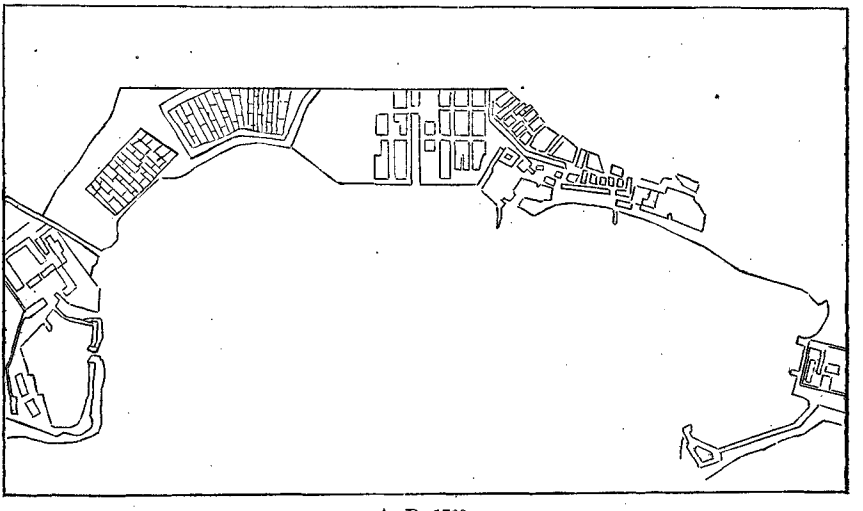
This general plan may be described as follows: An entirely new har-



A. D. 1650.

bor is being constructed near to and in part overlapping the present one. Three large basins will be formed separated from each other and from the other parts of the bay by moles or quays of masonry and earth work. A breakwater of similar construction will be placed parallel to the front of the line of the new front and at a short distance from it. The harbor thus formed will be dredged to a depth sufficient to accommodate the largest ships of the Austrian Navy. The quays and the neighboring land will be brought to a proper level for the lo-

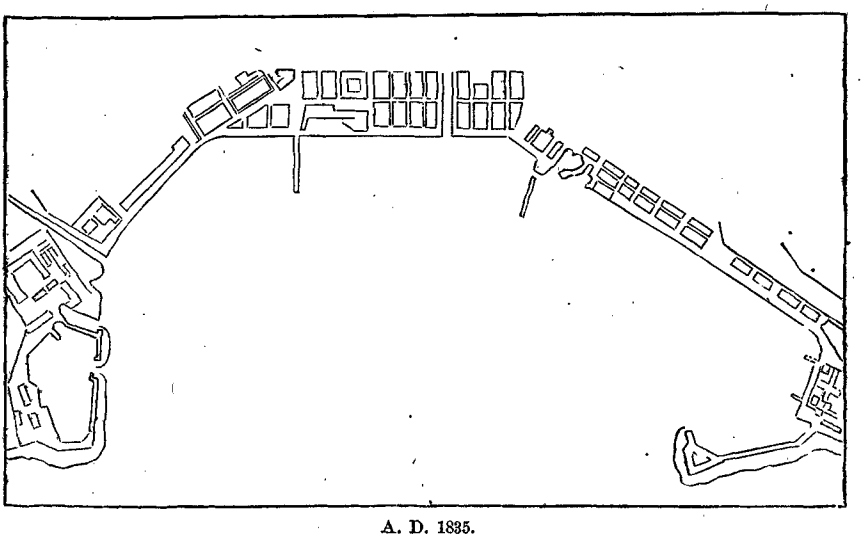
cation of railroads and warehouses for the benefit of commerce. In construction certain difficulties required caution. The bed of the harbor consists of a slime or mud of at least 66 feet in depth. The in



A. D. 1768.

stability of the retaining walls of the quays built over this foundation gave trouble which was overcome by—

(1) Dredging a ditch for the reception of the rock work.



A. D. 1835.

(2) A layer of good material (gravel mixed with fine limestone, &c.) of 10 to 13 feet thickness was placed throughout the whole length of these moles or quays.

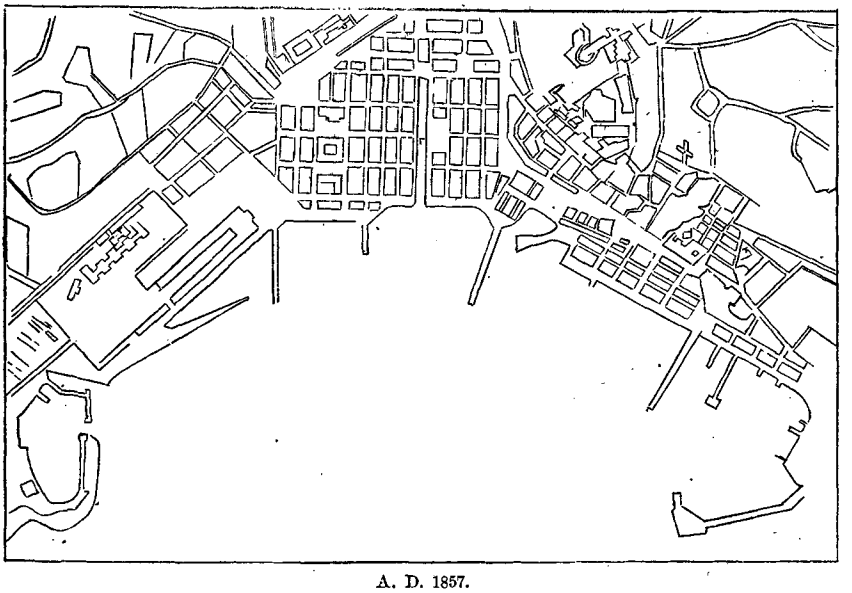
(3) In a full profile of the masonry work.

(4) In carefully executed retaining walls.

In weak places of these walls three rows of foundation blocks were placed instead of one, and strong counterforts, made of four blocks in height, were placed at distances of 1 yard from each other. The work done with these precautions has given good results up to the present time.

From the year 1868 to the end of 1875 the South Austrian Company constructed for the Government the following amount of work:

	Cubic yards.
Earth work	3,533,169
Rock work	1,619,566
Quay walls	125,830
Dredging	865,373
Total	6,143,938



A. D. 1857.

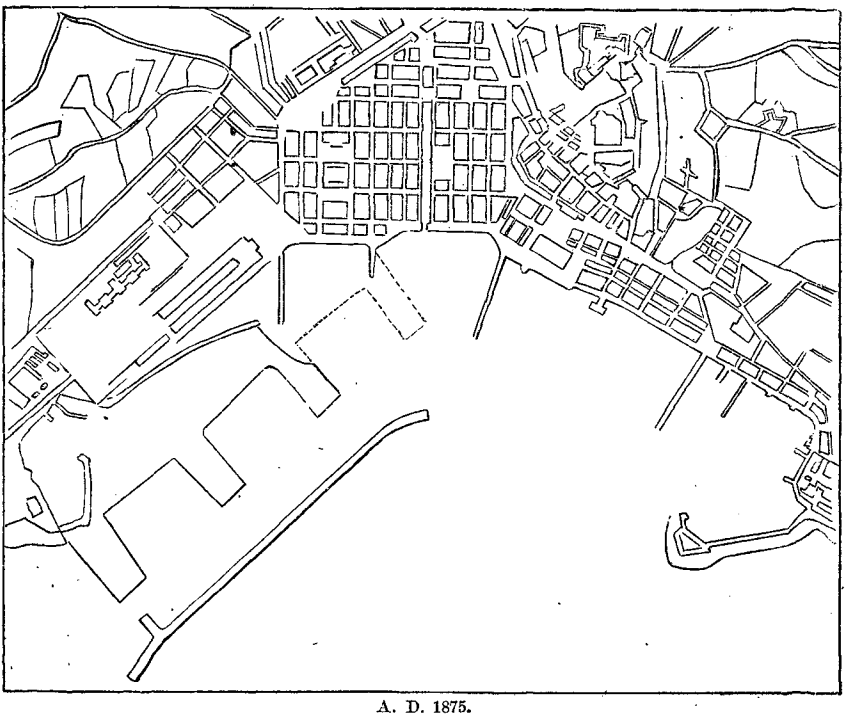
The breakwater was commenced in 1868, completed in 1874, and turned over to the Government in August, 1875. The surface of this work is equal to 2.82 acres, and the length of its quay wall is 3,960 feet inside to the harbor. The first basin was commenced in 1868, completed in 1875, and turned over to the Government in December, 1875. It has a depth of from 28 to 39 feet, and a surface area of 14.37 acres. The remaining work is unfinished, but the following figures give the condition when completed:

Surface of the second basin, 28 to 39 feet in depth, 14.85 acres.

Surface of the third basin, 28 to 39 feet in depth, 14.65 acres.

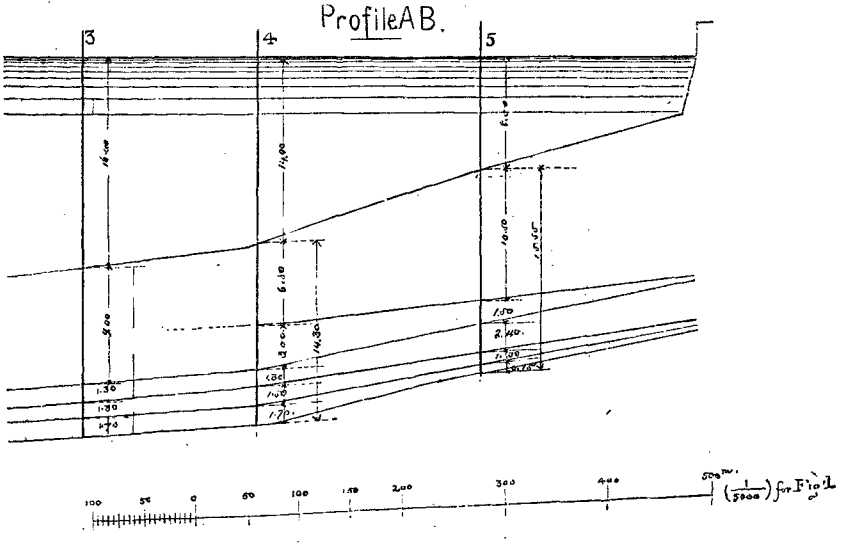
The protection of the new harbor from possible danger from two mountain torrents, Martesin and Klutsch, forms a part of the work, and

permanent sewers or sluices will be made. A new landing place will also be constructed, and this necessitates the destruction of nearly all



A. D. 1875.

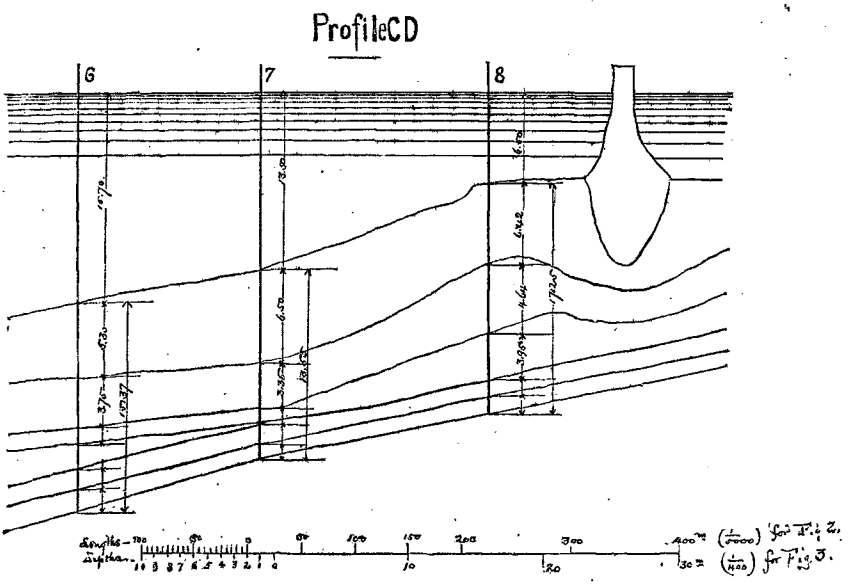
existing buildings on the chosen site and the lowering of the level about 23 feet. The goods warehouses are partially completed. The passen-



ger station, locomotive shops, and the remaining earthwork cuttings are all completed or nearly so. When the whole work is finished there

will be an available surface over the quays of 54 acres nearly, and over the four moles of 17⅓ acres. The length of the quay wall will be 7,687 feet. The surface of the entire landing yard or wharf will be 63.13 acres.

The foundations of the breakwater are placed 53 feet below low-water mark. The width is 212 feet. Ten feet of gravel and fine material form the center. A covering of 13 feet of broken stone is placed over this. The remainder consists of blocks of stone from 2.5 to 4 cubic

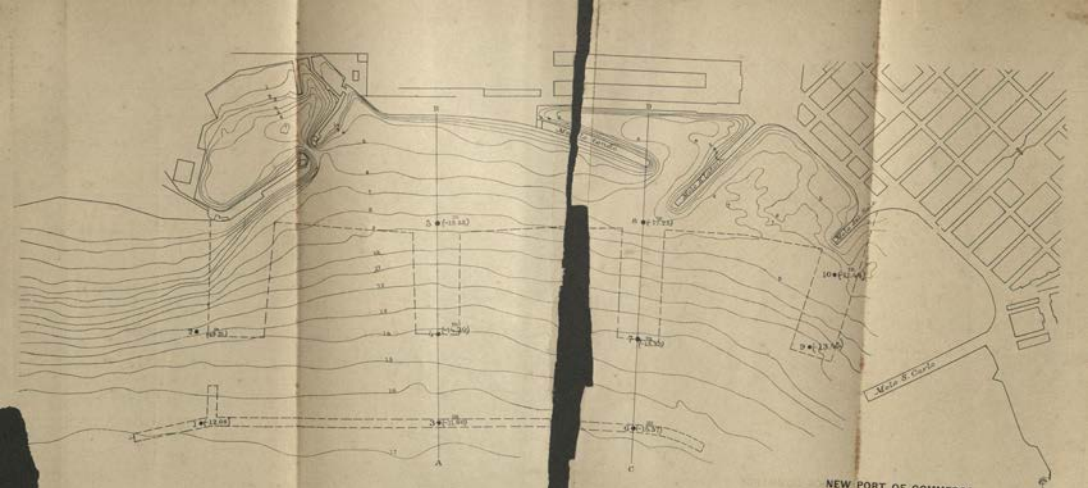


yards in size, and on the outer slope, within 15 feet of the surface, the blocks are larger. The inner and outer slopes are 3:2.

The quay walls of the breakwater are similar to those of the moles. They are 20 feet below low water; of concrete blocks, 12 feet through. Above low water cut-stone walls 10½ feet rise. The masonry is backed by concrete to a width of 6.5 feet. The slopes of the foundations of the moles are more gentle than those of the breakwater, and range from 1:2 on the first mole to 1:4 on the others. In the construction of Moles II and III the pressure of the earth filling is kept from the quay wall by an internal dike of broken stone, with a base of 100 feet and slopes presented to the earth of 2:3.

Sketches are submitted herewith showing the condition of the harbor in 1650, 1768, 1835, 1857, and 1875. A plate shows the contour lines of the harbor before the new work was begun, and profiles exhibit the depths before and after the work was done. These were copied from the manuscript volume of plates already referred to.

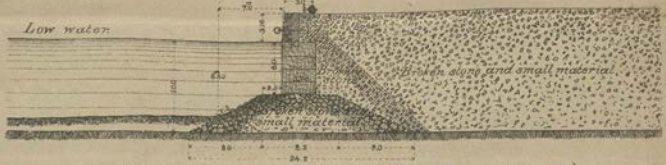
A cross-section (Plate 1) is given of the breakwater as completed, and longitudinal sections of the three moles or piers. Lastly, a plan (Plate 2) of the entire work as completed up to June, 1876, is furnished,



NEW PORT OF COMMERCE
at Trieste.

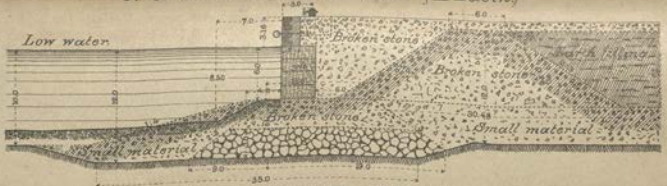
STANDARD SECTION OF CONSTRUCTION.

1. *Government standard section. (Pier I and wharf I.)*

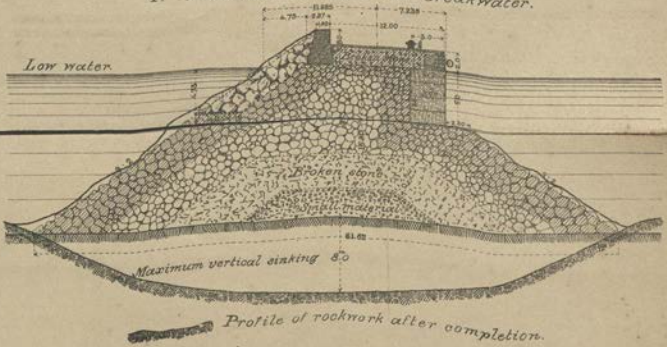


2. *Standard section modified. (Pier II and wharf II.)*

3. *Standard section modified. (III Basin.)*



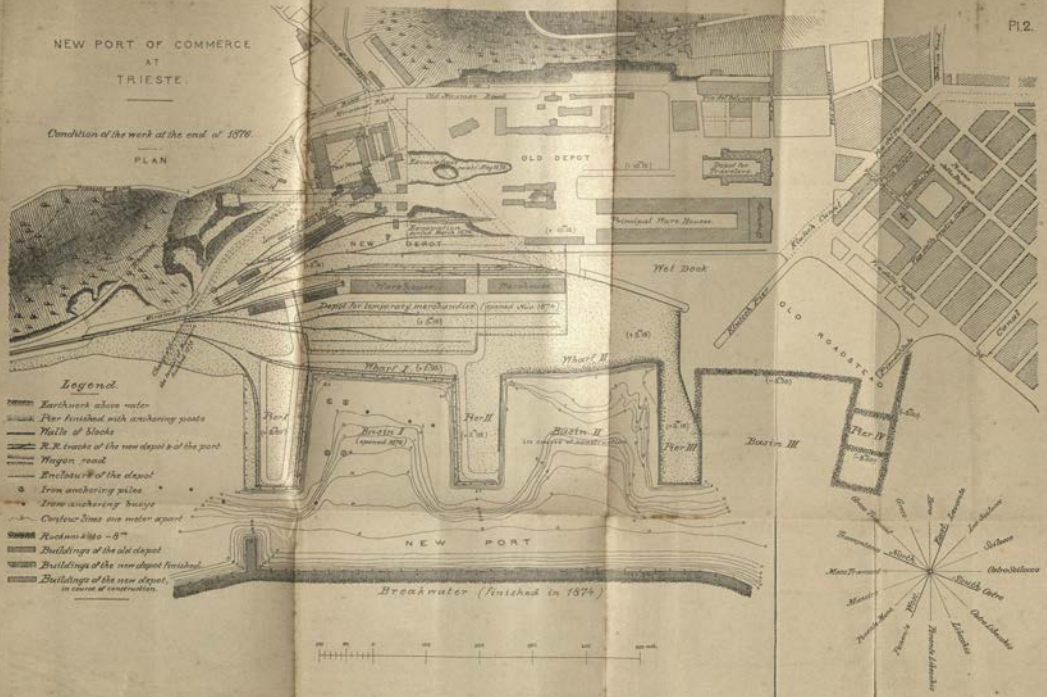
4. *Standard section of the breakwater.*



NEW PORT OF COMMERCE AT TRIESTE.

Condition of the work at the end of 1876.

PLAN



showing the harbor work and also the land work, or that necessary to prepare the landing and railroad depots.

Since the preceding was written (by Lieutenant Ruffner), there has been received from Mr. Fr. Bomches, engineer-in-chief of the new port of commerce at Trieste, an account of the system of construction as carried out, which I (Captain Heap) translate and insert here, as it contains some important modifications of the original plan.

SYSTEM OF CONSTRUCTION.

The muddy nature of the bottom, soundings to a depth of 20 meters showing only mud without reaching solid earth, requires the employment of a system of construction which would overcome the inconveniences resulting from the mobility of the earth and insure the solidity of the walls of the quays in spite of unforeseen movements.

When it is necessary to build on muddy ground, the main difficulty consists in contending against the enormous masses in movement, of which neither the time, direction, nor duration can be foreseen. In such cases building on piles is entirely excluded, for they would have to penetrate to very great depths, and would never assure the stability of the work. On the other hand, the use of pneumatic foundations would need excessive outlay on account of the enormous depths at which the solid earth would be met. The only means remaining, then, at the same time efficacious and economical, consisted in applying good material to the bottom in order to prepare a solid foundation for the quay-wall.

The system advantageously employed in the French ports consists in establishing submarine dikes of loose stone upon which the quay-walls rest by the intervention of a foundation of artificial blocks. When the walls are built the pier is finished by filling the interior with earth. The component parts of the pier are shown in the standard section (*profil-type*) adopted (see Pl. 1, Fig. 1).

The process described was followed in the first pier, without, however, leading to good results, notwithstanding that limestone was used almost exclusively even for the interior filling The difficulty was as follows:

(1.) Lack of sufficient resistance of the loose stone and wall of blocks to withstand the lateral thrust of the filling advancing as a whole and sliding upon the muddy bottom in the direction of the greatest inclination (south side and head of the pier), causing a general dislocation of the alignments of the quay walls, and in consequence a considerable alteration of the original dimensions of the work.

(2.) Penetration of several courses of artificial blocks in the loose stone on account of the entire body of the filling sinking considerably in the mud. This required the use of more than double the number of artificial blocks anticipated, on account of having to replace the sunken courses by others superposed upon them.

(3.) The necessity of repairing the walls of blocks which were changed as much in the horizontal as in the vertical direction; this was necessary in order to re-establish both the conditions of stability and the best alignment.

The experience gained in Pier I has led to essential modifications of the system described—viz:

I. Dredging a ditch below the loose stone in order to deposit them as deep as possible and to augment in consequence their resistance to lateral displacement due to the thrust of the filling. The dredging, only 8 to 9 meters deep in the first two basins, was pushed as far as 12 meters in the third basin. In order to increase the above-mentioned depth, large natural blocks, weighing as high as 4,000 kilograms (8,820 pounds), have been placed in the ditch, and their weight has caused them to penetrate the mud 3 meters more.

II. Establishing a general bed of good material (gravel and limestone chips), 3 to 4 meters thick, under the entire width of the pier.

III. The increase of the dimensions of the section of the loose stone by widening the berm and decreasing the slope.

IV. Establishing a dike of defense (*pari passu* with the loose stone) built of choice material, *i. e.*, of broken limestone, in order to protect the earthwork from the attacks of the sea.

V. Joining the parallel lines of the longitudinal quays by two traverses constructed of choice material like the dikes of defense, and at the same time with them.

VI. Building the walls of blocks *after the filling was completed.*

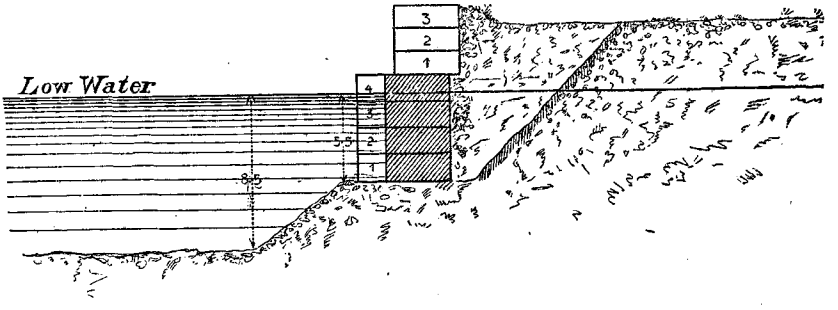
These modifications are shown in the standard sections adopted for the last two basins (see Pl. 1, Figs. 2, and 3).

The adoption of these modifications has eliminated the two inconveniences mentioned under 1 and 2, without, however, entirely preventing the alteration of the alignment of the quays and the consequent necessity of rebuilding the walls of blocks.

It should be mentioned here that the derangement of the alignments was partly due to the dredging done at the foot of the walls to remove the mud pressed up on account of the sinking of the entire body of the filling; the raising of this counterpoise aided the lateral thrust of the prism of the filling behind the blocks and thus facilitated the movement of the walls in a horizontal direction.

To diminish as much as possible this lateral movement and to transform it into a vertical sinking, a last modification of the system has been introduced, consisting in—

VII. The increase of the weight of the wall of blocks, not only by placing upon it three courses of blocks but also by establishing counterforts composed of four blocks superposed, the counterforts being placed in front of the wall and 1 meter apart. See drawing.



This course has given such good results on Pier III that the dredging at the foot of the walls north and south of the work could be carried to a depth of 8.50 meters without cracking the courses of blocks.

En résumé, the modifications introduced consist in dredging a ditch for the submarine dikes, in establishing a general bed of good material upon the site of the pier, in increasing the amount of loose stone, in constructing a dike of defense for the filling, and in changing the order of execution of the different details of the work.

These modifications in the works of the Basins II and III do not apply to the breakwater (see Pl. 1, Fig. 4). Here the horizontal plan of the bottom, the great depth of water, the symmetry of cross-section, the nearly exclusive use of natural blocks for the double purpose of solidity and economy, and the almost entire completion of the body of the breakwater, before placing the blocks, have contributed to a sensibly vertical descent of the work without producing any lateral movements.

FR. BOMCHES.

Trieste, Austria, November, 1876.

FRANCE.

The "Department of Public Works" of France exhibits a remarkably fine display of models, charts, drawings, and photographs of the works of the Corps des "Ponts et Chaussées" and of the "Mines."

The "Ponts et Chaussées" include the roads, railways, internal navigation, maritime works, light-houses and beacons, water supply of towns and canals, and "Central Society for the Rescue." The "Mines" include various geological maps of France.

A special building was erected by the French Government where the above objects were displayed with good taste and to advantage.

A descriptive catalogue was also published in both French and English, under the title of "Notices on the Models, Charts, and Drawings, relating to the works of the 'Ponts et Chaussées' and the Mines." Copies of this work were distributed on application to all engineers.

The following notices on engineering works in France were condensed from the above work:

NAVIGATION BETWEEN PARIS AND AUXERRE—SUBSTITUTION OF CONTINUOUS NAVIGATION FOR THE INTERMITTENT SYSTEM OF "ÉCLUSÉES" ON THE YONNE.*

The water communication between Auxerre and Paris follows the line of the Yonne between Auxerre and Montereau, for a distance of 119,586^{m}, and that of the Seine between Montereau and Paris for a distance of 98,000^{m}; total length, 217,586^{m}; the navigation between Auxerre and Paris was intermittent for more than three centuries, and during eight or nine months in the year, from March to November, was carried on by means of *éclusées* of the Upper Yonne.

The continuous system of navigation, procuring a minimum depth of water of 1^{m}.60, has been in operation since the month of September, 1871, between Paris and Laroche, and since the month of September, 1874, as far as Auxerre. This result has been brought about by the establishment of 12 movable barrages with locks, on the Seine, and 25 movable barrages on the Yonne. Twenty of these latter are provided with locks, and 3 come under the head of cuttings.

THE RIVER YONNE.

The course of the river Yonne between Auxerre and Montereau is divided into two parts. The first part, between Auxerre and Laroche, 27,616^{m} in length, is from 60^{m} to 80^{m} in breadth. The second part,

* Éclusées on the river Yonne are temporary and factitious risings of water, created by the regular and successive closing and opening of the navigable passages and barrages established along its course, and these bodies of water carry the various boats, rafts, &c.

from Laroche to Montereau, 91,976^{m} in length, has a breadth of from 80^{m} to 100^{m}.

Of the 25 locks on the Yonne, 22 have a breadth of 10^{m}.50 and a working length of 96^{m}; they are thus able to receive 6 canal boats or 2 rafts of wood coupled.

The 3 other locks, which are old, leave a breadth of 8^{m}.30; two of these, namely, Épineau and Port Renard, have a working length of 181 meters, and can also receive 6 canal-boats or 2 wood rafts. The third, that of Chaînette, at Auxerre, has a working length of 93^{m}, and can receive 3 boats or 1 raft.

All the gates of the locks are of wood, and each gate is worked by a circular rack and pinion with a winch.

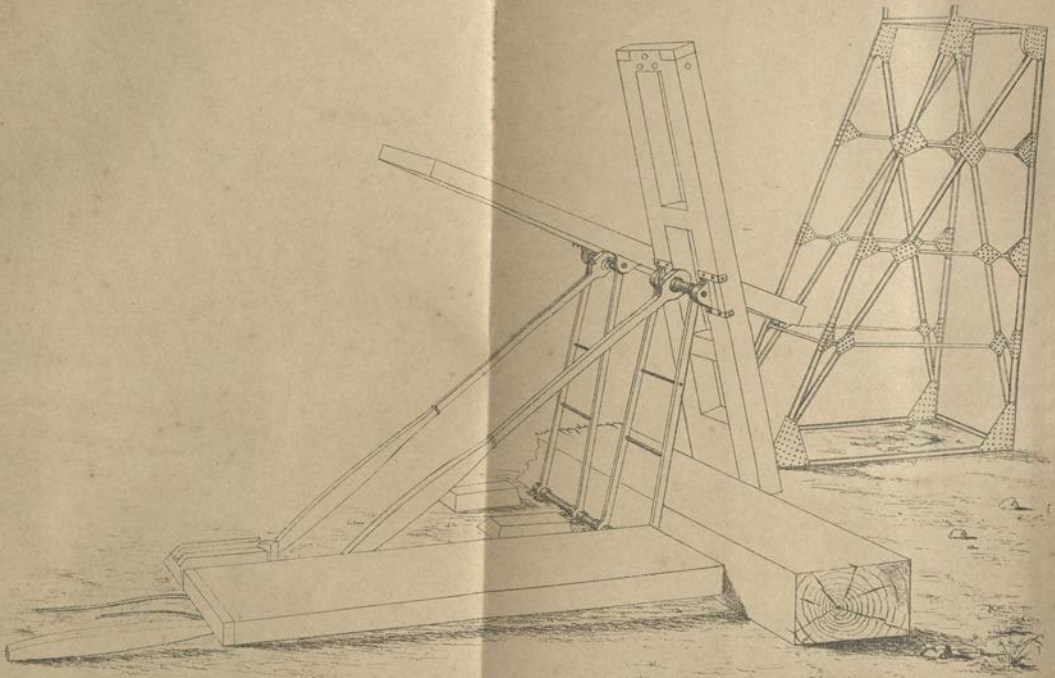
Between Auxerre and Montereau there are 25 movable barrages and 3 cuttings. Three of the 25 are old, and on the system Poirée; that is to say, they have a permanent or fixed weir, in masonry, and a passage closed by trestles and needles. These are the barrages of Chaînette, Épineau, and Port Renard. The 22 new barrages have a passage closed by movable shutters (Chanoine's system), worked by a bar furnished with cams, and by the aid of a boat. In 13 barrages between Laroche and Montereau, the weir is surmounted by movable shutters and worked by the aid of a foot-bridge, and in 6 between Auxerre and Laroche the weir is surmounted by trestles and needles, with a foot-bridge at least 25^{cm} above the head water level. This foot-bridge has not been raised to the usual height, owing to an apprehension that the needles might be difficult to work. One barrage only, that of l'Île Brûlée near Auxerre, is fitted with large shutters (Girard's system).

The sill of the passage is generally placed 50^{cm} or 60^{cm} below low-water mark, but the capping of the weirs of the 3 barrages, on Poirée's system, is level with the head water, the sill of the other weirs is 50^{cm} below low-water mark.

In order to avoid abrupt bends in the river, 3 cuttings have been made, viz:

	Meters.
That of Grugy, with a length of	5,007
That of Joigny, with a length of	3,574
That of Courton, with a length of	4,134

These three cuttings shorten the distance from Montereau to Auxerre, by 11,309^{m}. At the head of each cutting there is a stop-gate to keep out the flood water. The breadth at the bottom of each cutting is 16^{m}, and the depth below the normal level of the water 1^{m}.80, with a talus of 3^{m} of base for 2^{m} of height, which gives a breadth of 21^{m}.40 at the surface of the water. The banks or towing paths are from 4^{m} to 6^{m} in breadth and are elevated at least 50^{cm} above the highest inundations known. The passage under the bridges is reduced to 10^{m}.50, and the height of the intrados above the level of the water is 5^{m}.50.



MOVABLE SHUTTER WEIRS.

Chanoine System.

THE RIVER SEINE.

Between Montereau and Moret, for 12 kilometers, the Seine has a breadth of 100m to 110m. Between Moret and Paris the breadth is from 140m to 170m.

The navigable condition of the Seine between Montereau and Paris, previous to the month of September, 1871, was powerfully influenced by the system of "éclusées" on the Yonne, so that for nearly three-quarters of the year navigation was intermittent. This precarious and inconvenient state of things on a river of such importance as the Seine has ceased to exist since the month of September, 1871, owing to the construction of 12 barrages during the last few years, between Montereau and Paris. These 12 barrages are constructed on the Chanoine's system. The barrages at Melun have alone retained for the river the trestle and needle system in use on the right branch of the Seine.

Experience has led to the detection of some faults in the working of the original shutters, and a movable foot-bridge on trestles, with a plank flooring, has been constructed on the upper or head side of the shutter-weir.

MOVABLE SHUTTER-WEIRS ON THE UPPER SEINE ABOVE PARIS.

(Drawings and models.)

The barrages of the Upper Seine consist of two parts. A *navigable passage* from 40m to 50m and a *weir* of from 60m to 70m in breadth, provided with movable shutters. The two parts are separated by a pier, and a lock is generally joined to the barrage.

The sill of the navigable passage is placed 0m.60 below low-water mark. The shutters are 3m in height and are level with the water, which gives 2m.40 for the depth of the upper or head water above the low water mark.

A shutter consists of a wooden frame and of a wrought-iron trestle and prop; the trestle is a trapezium, strengthened by a cross-bar; the prop is a wrought-iron bar, and is intended to support the shutter and the weight of the head water. It is joined to the top of the trestle by a bolt, and the lower end abuts against a cast-iron shoe or catch, strongly imbedded in the flooring. This shoe, in the form of an inclined plane, is inserted into two widened ears, and has a guide-bar, much bent, terminated by an ear. When it is desired to lower the shutter, the end of the prop is removed, and as soon as it leaves the front of the shoe it slides along the guide bar, while the trestle, turning on its base, falls with the shutter on the flooring. To raise it the base is furnished with a broad iron handle, with which the keeper connects a hook attached to a rope. Then, by means of a small winch fixed in a boat for this purpose, the various parts are successively raised, the breech, the trestle, and lastly the prop, the foot of which moves up the inclined

plane, and resumes its place against the shoe. The fall of water assists this operation to a considerable extent, since it tends to raise the frame of the shutter, of which the axis of rotation is placed at a certain height above the sill.

The operation of opening a passage is performed from the bank, and by the aid of the winch, in 3 seconds per meter run, the closing is effected with a boat at the rate of 1¼ minutes.

The weirs of the Upper Seine are from 60^{m} to 70^{m} in length. They are leveled to 0^{m}.50 above low-water mark.

The self-acting shutters of the weirs are 2^{m} in height by 1^{m}.30 in breadth and are formed like those of the passages, according to the original system conceived by M. Chanoine, engineer-in-chief, *i. e.*, to rise and fall of themselves.

Owing to the position of the axis of rotation, these shutters raise and lower themselves, this axis being only raised 0^{m}.05 above the third of their height; there is also a movable counterpoise.

The striking simplicity of this ingenious system of shutters, called self-acting, led to some isolated experiments being made in a single barrage. But the working of the system being more completely tested by its application to twelve weirs on the Seine, between Montereau and Paris, some grave miscalculations were made apparent. The self-acting shutters lowered themselves too quickly, and did not rise till after a lowering of one meter of the upper or head water.

A foot-bridge, composed of iron trestles on the Poirée system, was constructed above each weir to work the shutters. The counterpoises, being no longer useful, have been removed.

The new system has been a complete success. At night every keeper is warned of any variations in the upper water of the barrage, by the ringing of a bell put in motion by a float. In addition, all the barrages communicate with each other by telegraph, and the excellence of the arrangements precludes the possibility of surprise.

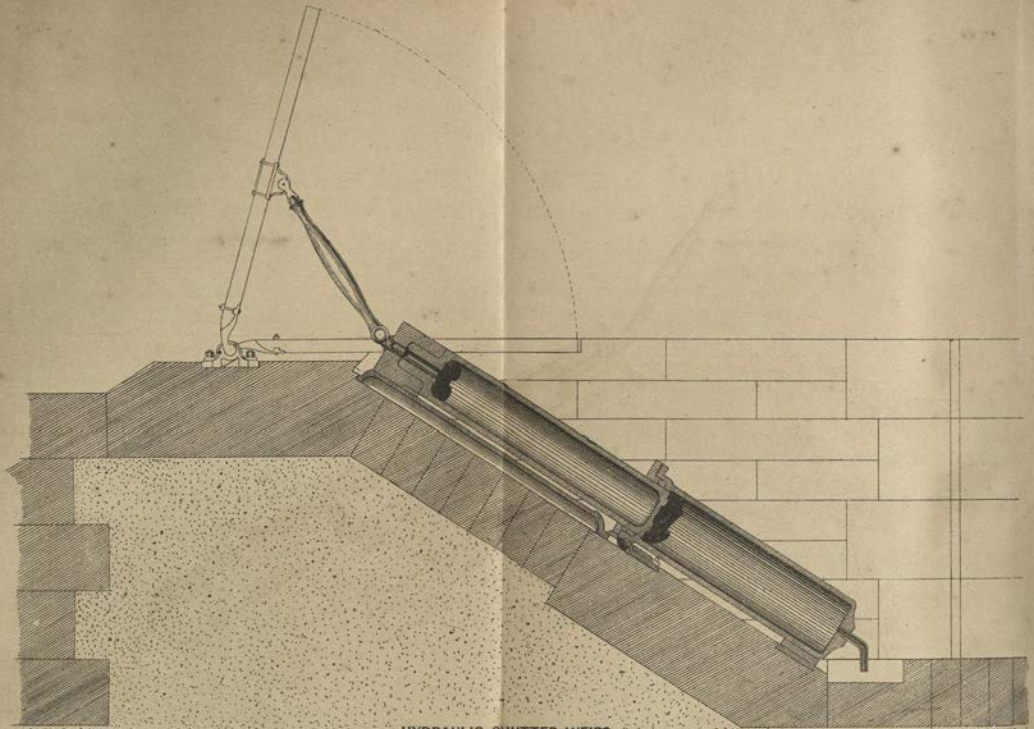
NEW NAVIGABLE PASSAGE OF THE PORT-À-L'ANGLAIS BARRAGE.

In consequence of fresh arrangements for establishing an uninterrupted passage by the Seine to Paris, it became necessary to lower by 1^{m} the tail sill of the lock at Port-à-l'Anglais; this required, to sustain the increased pressure of water, a corresponding increase in the height and strength of the shutters.

The new shutters are 3^{m}.70 by 1^{m} (instead of 3^{m} by 1^{m}.20); the framework is simplified, the inclination increased from 8° to 20°, and the axis of rotation placed only 15^{cm} below the axis of figure. Small butterfly valves have been contrived to prevent the shutters from turning spontaneously.

The shutters are worked from trestle bridge (Poirée's system), on which travels a winch.

(See page 688, Chief of Engineers' Report, Part 1, 1875, for more detailed description.)



HYDRAULIC SHUTTER WEIRS.

Girard System.

WEIR OF THE BARRAGE OF L'ÎLE BRÛLÉE ON THE YONNE.

(M. Girard's system of sluices and hydraulic presses, drawings and a model.)

The weir of l'Île Brûlée is surmounted by large sluices invented by M. Girard, civil engineer. This system comprises—

(1.) A series of wooden sluices, movable round a horizontal axis and capable of turning inside a cast-iron cylinder, or case, let into the top of a stone flooring.

(2.) Hydraulic presses fixed on the lower slope of the platform, solidly anchored in the masonry and intended to work each sluice. The piston-rod of each of these presses carries a cross-beam guided by slide bars, by which it is supported, and to this cross-beam are fitted three connecting rods joined to another cross-beam attached to the middle of the movable sluices.

(3.) A series of copper tubes, which put each press in communication with the generators and reservoirs of force, destined to convey the water under pressure to the hydraulic presses.

(4.) A hydraulic machine constructed on the abutment of the barrage. This machine consists of a turbine with vertical axis, a double-action pump worked by the turbine, and a generator. The pumps and generator communicate with each other and with the presses by the medium of three-way cocks, which allow the water to be forced back either into the generator or into the presses, or to be discharged into a waste pipe.

The working of the sluices is performed by the simple action of these cocks. By putting each press in communication, either with the pumps or with the reservoir, under sufficient pressure an upward movement of the piston is produced, and the sluice rises. On the other hand, by opening the discharge cock the water escapes under the pressure of the sluice valve, the body of the pump is emptied and the sluice is lowered. The reservoir of force regulates the action of the pumps; it also allows the sluices to be raised when there is not sufficient fall to work the turbine.

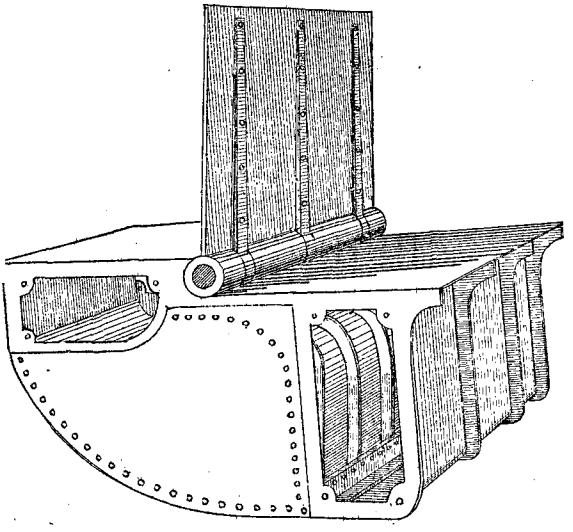
The cost of construction of this system of barrage is 2,000 francs per meter run, and 3,000 francs with the stone-work.

The trestle and needle weir costs only 1,200 francs per meter run, everything included, in this part of the Yonne where the foundation work is not difficult. The hydraulic press system, notwithstanding its superiority in convenience of working, has the disadvantage of being very costly.

(See page 688, Chief of Engineers' Report, Part I, 1875, for more detailed description.)

MOVABLE WICKET WEIRS OF THE BARRAGES ON THE MARNE.

(Desfontaine's system.—Model.)



Drum shutters.—Desfontaine's system.

Between 1855 and 1867 fourteen barrages were constructed to improve the navigation of the lower Marne, between Epernay and Charenton (Seine), a distance of 178 kilometers. Of this number eleven comprise a weir fitted with movable wickets, in addition to a lock and navigable passage. The excellence of this system has now been completely tested by the experience of eighteen years, and was invented by the late M. Desfontaines, chief engineer of the navigation of the Marne, afterwards nominated inspector-general des ponts et chaussées, and who died in 1867.

General idea of drum shutters.—Let the reader imagine an iron plate sluice or valve, 2 meters in height by 1^{m}.50 in breadth, movable around a horizontal fixed axis, and capable of describing a quadrant. If the axis is placed at the top of the fixed weir, the upper part of the valve will form a movable wicket, while the lower part or counter-wicket moves in a species of drum, the axis of which is horizontal. The transverse section of this drum, parallel to the axis of the river, consists of a quadrant joined on the lower or tail side by a rectangle.

The wicket is moved by the counter-wicket, and the motive power is the pressure resulting from the difference between the upper and lower water valves, or in other words, the head and tail of the barrage. It is therefore a question of the effective application of this power to the counter-wicket.

If the drum is closed at the ends by two vertical plates, and covered on a level with the axis of rotation by a horizontal plate, a closed box

will be formed divided into two compartments by the counter-wicket, two sectors, the dimensions of which vary according to the position of the counter-wicket. When it turns, the counter-wicket nearly touches, or within 3 or 4 millimeters, the cylinder and the vertical ends of the drum. But when, with the wicket, it is in a vertical position, a ledge or projection completely stops its passage, and by the aid of an india-rubber band, the surface of contact is rendered perfectly water-tight.

This counter-wicket does not, however, prolong the wicket; it is bent from the hinge and only resumes a position parallel to the wicket at a distance of $0^{m}.30$ or $0^{m}.40$. It follows from this, that the wicket being in a horizontal position, the counter-wicket, though also horizontal, leaves a space of $0^{m}.40$ between it and the cylinder. Now by putting this space in communication with the upper water level, while the lower space, more or less empty, is put in communication with the lower or tail-water, the counter-wicket will descend and the wicket will rise, notwithstanding the static and dynamic pressure, which tends to retain the wicket in a horizontal position.

M. Desfontaines has contrived a culvert with valves, in the abutment barrage, by means of which the water can act as above.

Historical.—At the present time, when Desfontaine's system is to be officially presented to the notice of American engineers, it may not be out of place to supplement the preceding notice by a few explanatory remarks concerning its origin and development.

This system appertains to a class of barrages, of which the prominent and common feature consists in the fact of the fall constituting the motive power. In Holland, from time immemorial, fan gates have been employed to close the irrigation canals. The unequal breadth of this kind of gate renders it susceptible to the power generated by a moderate lift. This method is still in use at the present day, and was represented by a model in the Universal Exhibition at Vienna in 1873.*

Probably the idea passed from Holland to America, for about the year 1818 it was applied on the river Lehigh, in Pennsylvania, not in the form of gates with vertical quoin-posts, but with horizontal axis. It was noticed in the work of Michael Chevalier published in 1843, and advocated by M. Mary, the result of which was its trial in France, on the upper Marne, by MM. Desfontaines and Fleur Saint Denis. Although the work could not have been in more skillful hands, the first expectations were not realized. But this attempt failed not to leave in the inventive mind of M. Desfontaines the germ of an idea, which carefully considered and diligently elaborated has produced the present system.

The French Government now returns to the United States the American barrage perfected under French auspices.

*Also exhibited at this International Exhibition in the Netherland section. See Blaukin's gates.

MOVABLE TRESTLE BARRAGE AT MARTOT ON THE SEINE.

(Models.)

The works of the Martot barrage consist of a lock, of which the chamber is 105 meters by 12 meters, a first barrage connecting the lock with Geoffroy Island, a weir, with self-acting shutters, between this island and the island of Moine, and a second barrage between the island of Moine and the left bank.

This last, a part of which is represented by the model, is composed of three passages, 51 meters in breadth, between two abutments and three piers, the former 6 meters and the latter 4.10 meters in thickness by 8 meters in length.

The movable trestles are established according to the system of M. Poirée, and are sustained and bound at the top by bars above and below the weir. The up-stream bars, that support the needles, are formed of two flat bars of iron riveted to each other and having at each end a hole fitting the trestle gudgeon. The down-stream bars are in round iron.

The service bridge consists of three rows of planking upon three trestles, and is furnished beneath with flanges which clasp the T irons to prevent slipping; the planks are also held by small clasps.

The trestles have no system of escape for the water; the needles, which are of pine, have to be placed or moved by hand one after the other.

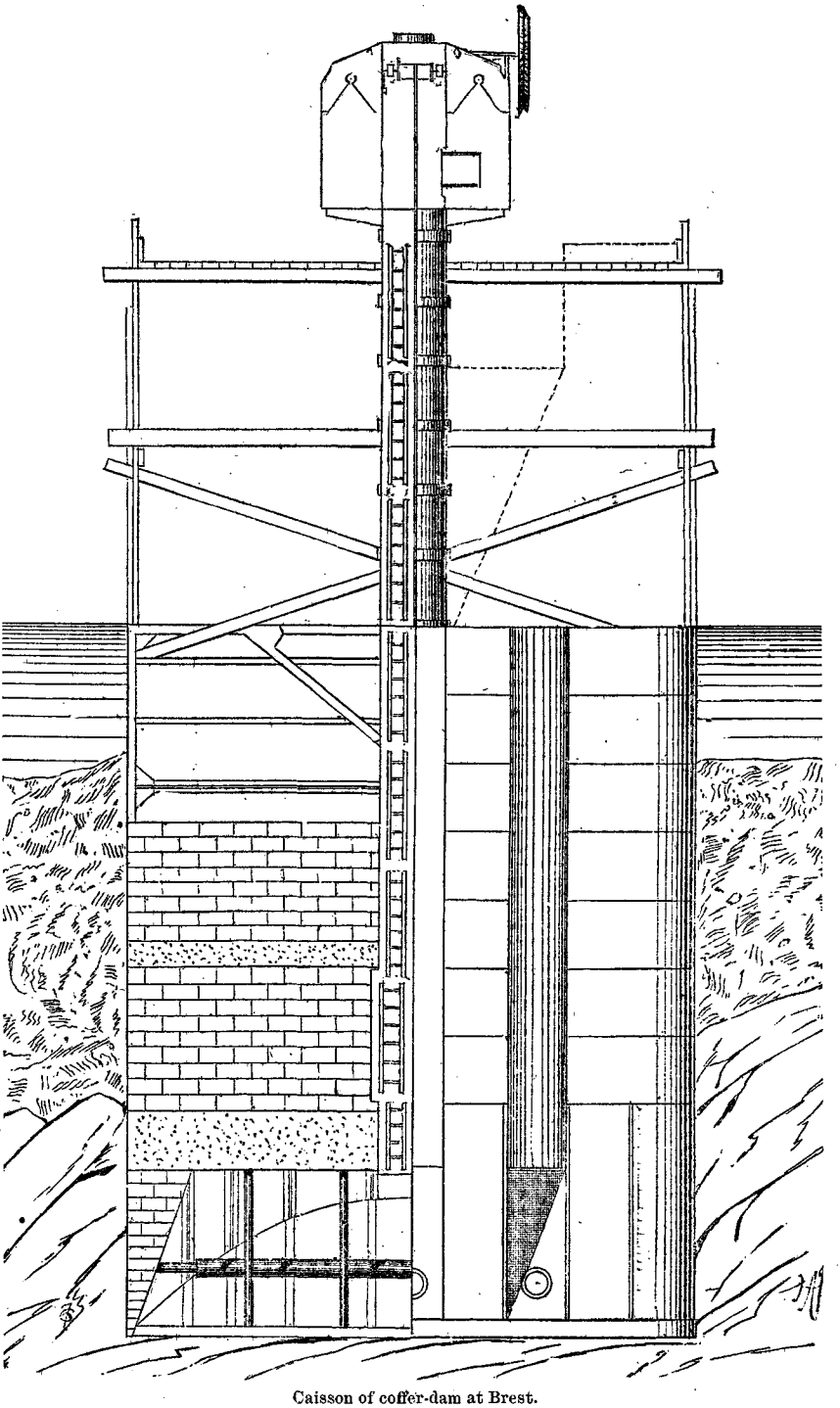
The cost of this barrage, including earth-work, dredging, pumping, accessory works and direction, amounted to 708,000 francs, or 4,050 francs per meter run.

For further information regarding movable hydraulic gates and dams the reader is referred to report by G. Weitzel, major of Engineers, brevet major-general, U. S. A., and W. E. Merrill, major of Engineers, and brevet colonel, U. S. A., 1875, Forty-third Congress, second session, Executive document, 78.

CAISSON OF THE COFFER-DAM OF THE BASIN AT BREST.

(Drawings.)

In 1867 it was found essential to replace the basin of oldest date in the port of Brest. The new one required a length of 112^{m}.70, a breadth of lock 21^{m}.70, and 8.^{m}50 of water in the lock at the lowest neap-tides. For this purpose it was necessary to construct a coffer-dam founded on the compressed-air system, by means of a unique caisson 27 meters in length by 8^{m}.50 in breadth, and 10^{m}.50 in height, attached at one end to a wall of masonry previously built, and at the other to the solid rock; also to erect a general wall upon the whole.



Caisson of coffer-dam at Brest.

This work was remarkable for the exceptional dimensions of the caisson, the necessity of removing the apparatus, and the difficulties occasioned by tidal movements.

At the bottom of the caisson was a large working chamber, strengthened in various ways and divided into three parts, each provided with a shaft surmounted by an air-chamber.

Above this first chamber was a second, 21 meters in length and intended to facilitate the taking to pieces that part of the caisson which was to be removed at the termination of the works, in order to leave the entrance of the basin clear of obstruction.

The lower part, comprising the working chamber, was obliged to be lowered sufficiently to allow the free passage of vessels; and it was considered more advantageous to preserve it, as a protecting wall in front of the lock, than to remove it. This conviction suggested the plan of a double working chamber, and a caisson in two parts, each of which constituted a separate caisson and was fastened to the other by bolts.

Above the second working chamber was an open compartment, which could be closed and rendered air-tight if necessary. This compartment was divided into two parts, one 21 meters in length, corresponding to the portion of the caisson which was to be removed; the other, 6 meters, in the line of the quay wall and intended to remain in its position.

At each extremity were three large grooves, 1 meter in section, descending vertically to the bottom of the lower chamber, of which the side opposite the rock was extended by an inclined plane, in order to fit the edge of the caisson.

These grooves were open next to the rock, and were destined, by filling them with beton, to form an air and water tight connection between the caisson and the side of the rock. A manhole was contrived in the lower part, in the inclined plane just mentioned, so that from the working chamber the grooves could be cleaned before filling them with beton.

In July, 1867, this caisson was put together in one of the graving docks of the port of Brest, and when finished weighed 170 tons.

In September it was ballasted with stone-work, increasing the weight to 240 tons, then taken like a boat to the spot required, and grounded in the precise position previously assigned to it.

At the commencement of the sinking, the work suffered considerably from tidal agitation until the caisson was sufficiently weighed to admit of injecting air and carrying on the work continuously in the chamber.

Two blast engines established on the bank, and moved by a 30 horse-power engine, conveyed to the working chamber nearly 400 cubic meters of air per hour.

A portable engine, also on shore, worked the three hoists established in the shafts by means of transmission lines and pulleys.

The excavated earth was discharged into mud-lighters alongside the caisson.

To avoid injury to the edge of the caisson by the weight of the stone-

work, it was supported inside the working chamber by shores resting on the rock, and tightened at the upper part by means of wooden soles and wedges.

The masonry above the working chamber was built with mortar of 1 cubic meter of sand to $0^{cm}.55$ of hydraulic lime and 100 kilograms of Portland cement.

The portion of the coffer-dam above the side of the caisson was constructed without difficulty at low water.

The junction of the caisson with the sides of the basin required particular care, and necessitated the employment of diving apparatus in order to thoroughly clean the grooves.

The work was finished in April, 1868. The filtration was only 10 cubic meters per hour.

In April, 1869, the works of the basin being finished, the demolition and removal of the coffer-dam were proceeded with. For this purpose, before letting the water into the basin, and by continual pumping, the part of the caisson to be removed was detached as completely as possible from the masonry to which it adhered. This was accomplished by opening two little galleries at the two extremities, to nearly 50 centimeters from the exterior facing. The water was then allowed to enter the basin. At the rising of the tide the masonry above the caisson was demolished. The stone-work in the open compartment was also demolished at the flow of the tide, but pumping was necessary to carry out this work.

The demolition of the masonry in the second working chamber was commenced in open air. A longitudinal gallery was made, before replacing the air-chambers on the shafts, and the work was then continued with compressed air. The masonry was then removed. Then, the caisson being sufficiently freed from weight, the bolts holding it were drawn, and it floated by pumping out the upper compartment. This operation was successfully performed on 26th June, 1869. In short, the construction of the coffer-dam was accomplished in seven months, and its demolition in two months and a half.

These works were executed by contract, at a cost of 376,000 francs, without reckoning 4,640 francs for the extraction and clearance of wood, iron, &c, from beneath the edge of the caisson.

IMPROVEMENT OF THE SEINE MARITIME, FROM ROUEN TO HAVRE.

(A drawing and a longitudinal section.)

For the entire distance of 127 kilometers between Roen and Havre the navigation of the Seine is completely free. There is neither rock nor bridge, nor obstacle of any kind, to obstruct the progress of vessels. With the exception of the passage of the Meules, between la Maille-raye and Candebec, 62 kilometers from Rouen, the draught of water, at the weakest flood tides, exceeds 5 meters. And even in the Meules during

the year 1875 there were only twelve days when the anchorage was less than 5 meters.

In 1845, the average tonnage of 4,795 vessels entering Rouen with cargo was 102 tons. In 1875 the number of vessels entering was 1,440, carrying 416,833 tons of goods. The average tonnage thus attained to 289 tons per vessel.

In the same year, 1875, two days after the first quarter of the moon, and consequently neap-tide, there entered Rouen a steamer laden with 1,080 tons of oats, and drawing $5^{m}.19$ of water. On the 7th September, the very day of the first quarter, another steamer entered, laden with 1,050 tons of goods and drawing $5^{m}.33$. In short, the premiums of insurance, which were formerly one-half per cent. for the single journey of the Seine, are negotiated to-day at the same rate for Rouen as for Havre.

These prosperous results are owing to the improvement of the Seine, by means of various works undertaken by the Government since the year 1848, and which consist in narrowing the bed of the river by embanking in stone parallel to the stream.

This system was applied for the first time at the crossing of Villequier, one of the most dangerous passages of the Seine. Two longitudinal embankments, 300 meters apart, and made flush a little above the average high water at spring-tides, had the desired effect, and a depth of $6^{m}.50$ was created below this level, where formerly was only $3^{m}.50$.

This success fully bearing out the expectations of the engineers, the embankments were continued, and, from 1849 to 1866, they were extended as far as the mouth of the Risle, 32 kilometers below Villequier. In addition to this, the southern embankment was established for 2 kilometers below the Risle. Above Villequier, embankments were formed for 11 kilometers of total development. This part of the work was executed in short lengths, from 1852 to 1875, so as to reach la Maille-raye, a small river port 60 kilometers below Rouen.

With respect to the interval between the embankments, it increases progressively after leaving la Vaquerie, where the width is still 300 meters, as at Villequier. Before Quillebœuf it reaches 400 meters, and at Tancarville, 500. From this point, as far as the Risle, the embankments are exactly parallel.

Between the Risle and the great depths of water in front of Havre the Seine has regularly kept to the southern part of the bay since the winter of 1871–1872.

The sides of the navigable channel are clearly indicated by beacons, carefully kept in order. An official report of the soundings, drawn up every fortnight, keeps the pilots informed of the number of meters and centimeters necessary to be added to the indications of the semaphores of Havre and Honfleur. By this means they know, at any time of the day, the minimum depth of water throughout the whole length of the channel.

All the embankments have been constructed with blocks procured from the chalky hills bordering the Seine. They measure, on the average, one-eighth of a cubic meter, and are piled one upon the other. The facings, starting from the level of ebb-tide, and the cappings are the only parts laid by hand. Generally speaking, the embankments are 2 meters in breadth at the top, and on the land side the talus is inclined to 45°, while on the channel side the inclination varies in proportion to the nature of the bottom and the violence of the currents of ebb and flow, so that at certain points the base is 7 or 8 meters for one meter in height.

These works are, for the most part, on the same level as those of Villequier. By way of experiment, some low embankments, leveled to 2 or 3 meters above the lowest water-mark, have been formed, in the first instance just below Tancarville, and recently on the left bank of the river between la Maille-raye and Candebec. This last attempt appears more likely to succeed than the other, doubtless on account of the greater tranquility of the water.

From the commencement of the works till the 31st of December, 1875, the cost of the first establishment and of heavy repairs was 16,860,000 francs. This sum includes 220,000 francs for deepening the peaty bottom of the passage of the Meules, which was accomplished by means of dredging.

In order to complete the repairs and secure the embankments against the attacks of the river and damage by frost, a further outlay of about 2,500,000 francs will be necessary, commencing from the 1st January, 1876. The passage of the Meules will also require to be deepened, so that at the lowest flood-tides there may be 5.30 meters of water. The expense on this head will reach 150,000 francs.

Finally, a sum of 4,000,000 francs will be devoted to the following works, conformably to the act of the 14th December, 1875: Reconstruction of the quays at Rouen; completion of the lighting of the Seine; straightening and clearing the defective passage of Croisset and Bardouville (4 and 25 kilometers below Rouen). This latter operation will be effected by dredging. The total of these expenses will amount in round figures to 21,500,000 francs.

In addition to the advantages derived from an increased depth of channel, the construction of embankments has caused the formation of about 8,400 hectares of alluvial land, of which 6,350 hectares constitute, at the present time, meadows of excellent quality.

In proportion as these reclaimed lands become consolidated, they are transferred to the proprietors along the river side, conditionally upon payment to the State of indemnities fixed at half the value of the lands required. The total of these collections will probably amount to 5,900,000 of francs.

LIGHTS AND BEACONS ON THE COAST OF FRANCE.

On the 1st of January, 1876, there were 379 light-houses, not including those of Algeria, and this number was classified as follows:

Light-houses:	
Of the first order	45
Of the second order	6
Of the third order	31
Of the fourth order	33
Of the fifth order	254
Floating lights	10

Two hundred and ninety light-houses have been constructed or renewed since the commencement of 1848. Up to that period the establishment of maritime beacons had not been seriously undertaken.

A description of a few of the more important light-houses will be found in the following pages.

LIGHT-HOUSES.

But one foreign nation—France—has made any attempt at an exhibit of this important branch; a few other nations have shown some photographs, but France displays models, drawings, and pictures of most of her best works in this line, from which I have selected a few typical ones illustrating different methods of construction.

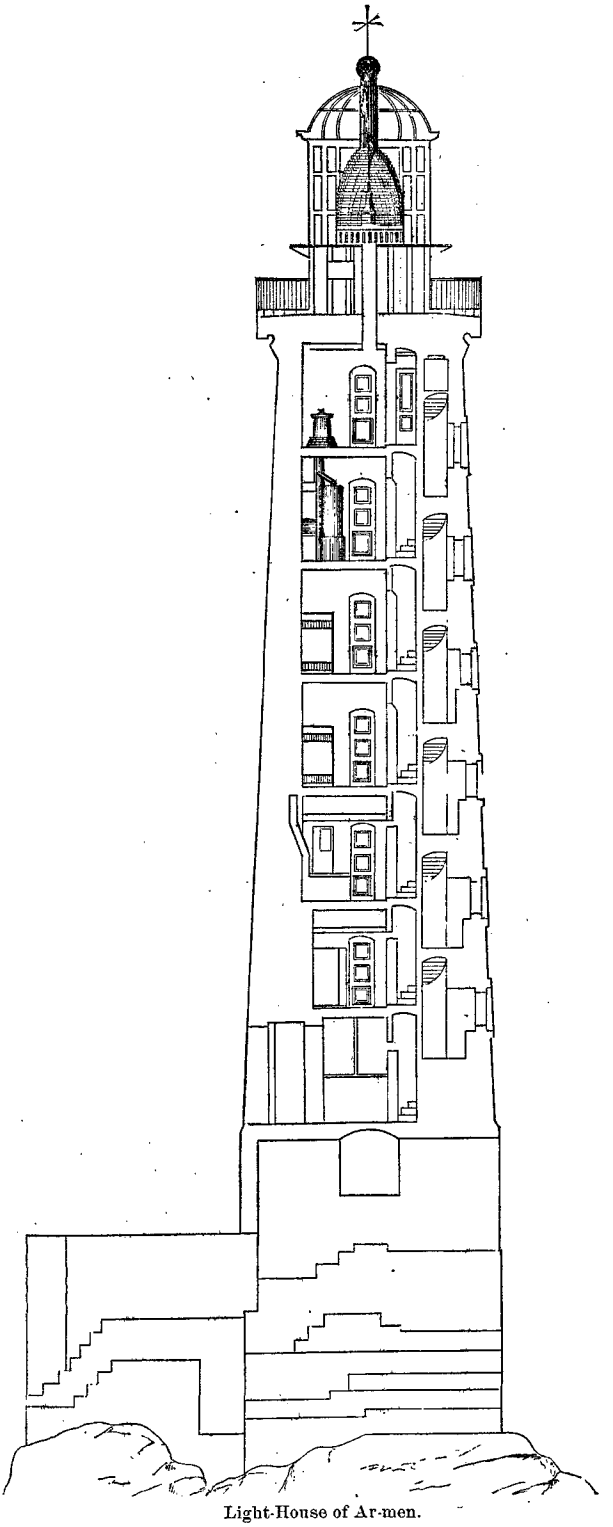
I have purposely omitted reference to the lenses and the subject of lighting in general, as Lieut. Allen Paul, U. S. N., gives this subject his attention in his report.

For full information concerning European light-houses I would refer to Major Elliot's valuable work entitled "Report of a tour of inspection of European light-house establishments, made in 1873," by Maj. George H. Elliot, published at Government Printing Office, 1874, and to "Memoir upon the illumination and beaconage of the coasts of France, by M. Léonce Reynaud," translated by Maj. Peter C. Hains, Corps of Engineers, and published at the Government Printing Office, 1876.

Light-house of Ar-men.

(Drawings on scales of 0.015 and 0.04 meter.)

The island of Sein is situated on the western extremity of the department of le Finistère, and extends in a westerly direction by a succession of reefs to a distance of nearly 8 miles from the island, and lower proportionably. The tops of some are elevated above the highest tides; others are alternately above and below the surface of the water, while the greater number are always submerged. They constitute a sort of dam, the direction of which is nearly perpendicular to that of the tide-currents, and the sea almost constantly breaks over them with extreme violence.



Light-House of Ar-men.

In April, 1860, the Light-House Commission demanded that the subject should be properly investigated, in order to know if it would not be possible to erect a light-house of the first order on one of the rocks not covered by the sea, and as near as possible to the extremity of the causeway. The idea was approved on the 3d June following, and the first surveys of the locality were confided to a commission composed of engineers and officers of the Navy. In July of the same year this commission had made a careful examination of the local conditions, and had ascertained that the heads of three rocks emerge from the water near the extremity, even in strong tides. Of these rocks, which bear the names of Madion, Schomeour, and Ar-men, the two first are nearly covered, while the third rises to about 1.50 meters above the lowest ebb-tides. The state of the sea had not permitted them to go alongside Ar-men, but its dimensions appeared insufficient for the construction of a great light-house, and it appeared impossible to land, however favorable the weather might be. The commission were therefore unanimous in proposing as a site the rock Neurlach, which is situated 5 miles inwards from the extremity of the causeway. This idea was repudiated by the Light-House Commission, as not tending to ameliorate the existing state of things sufficiently for the requirements of navigation, and the ministry of marines was requested to command a thorough hydrographic exploration of the extremity of the causeway.

Various circumstances retarded the execution of this work. In 1866, M. Ploix, engineer and hydrographer, was sent to the spot, and if he was not able to gather all the information necessary, still his investigations enabled the Commission to decide upon a plan. M. Ploix arrived at the conclusion that Ar-men was the most proper site.

"It is a work," said he, "exceedingly difficult, almost impossible, but considering the paramount importance of lighting the causeway, we must try the impossible."

The currents passing over the causeway of the Sein are in fact most violent; their speed in high tides exceeds eight knots, and in the calmest weather they cause a strong chopping sea, and render the water very rough as soon as a breeze from an opposite direction meets them. There is no land to shelter the rock against winds from between the north and east-south-east round to the south, and it is only possible to go alongside during very gentle winds between north and east.

To anchor a floating light at the extremity of the causeway had been recognized to be impossible, as much on account of the great depth of water as in respect of the bottom being thickly studded with rocks, around which the holding cable would be entangled. Neither was it possible to entertain the idea of establishing an iron structure resting directly on the reef, as the construction would be too difficult.

Taking into account the various considerations, the Light-House Commission, in its sitting on the 29th November, 1866, gave an opinion that

a solid foundation of masonry must be established on the rock Ar-men, and that it must be of such dimensions as would be suitable for the ultimate construction of a light-house.

The dimensions of the rock, which was tolerably hard gneiss, were ascertained to be 7 or 8 meters in breadth by 12 to 15 meters in length at the level of ebb-tides; also that the surface was very unequal and divided by profound fissures and that while almost perpendicular on the eastern side there was a gradual slope on the western.

The following mode of construction was therefore decided upon, viz: To bore holes 30 centimeters in depth and 1 meter apart all over the site of the intended edifice, and some other holes outside this limit, in order to hold the ringbolts necessary for craft coming alongside and to fasten the shrouds. The object of the first set of holes was to receive wrought-iron gudgeons to fix the masonry to the rock, and to make the construction itself serve to bind the different parts, and fissures, and thus consolidate a base the precarious nature of which gave rise to some misgivings.

It was proposed that in addition to these gudgeons others should be added, and strong iron chains introduced horizontally into the masonry, in proportion to its progress, so as to prevent any possible disjunction.

For the work of boring the holes the services of the fishermen of the isle of Sein were called in requisition, since their calling familiarized them with all the rocks of the causeway, and they were in a position to take advantage of every favorable opportunity. After many difficulties, they accepted a contract, the Government agreeing to furnish tools and life-belts.

In 1867 they went vigorously to work, and hastened to avail themselves of every possible chance of working. Two men from each boat landed on the rock, and, provided with their cork belts, lay down upon it; holding on with one hand and using the jumper or hammer with the other, they worked with feverish activity, the waves constantly breaking over them. One was carried off the rock, and the violence of the current bore him a long distance from the reef against which he would have been dashed to pieces. However, his life-belt kept him up, and a boat went to fetch him back to work. At the close of the season seven landings had been effected, and eight hours of work accomplished, during which fifteen holes had been bored in the highest parts of the rock. It was the first step towards success. In the following year greater difficulties were encountered, since it was necessary to commence on the point hardly above the surface of the water; but the experience gained was valuable, and a higher rate of remuneration gave additional encouragement to the fishermen; the season was favorable, sixteen landings were effected, eighteen hours of work accomplished, forty new holes bored, and they even succeeded in partially leveling and preparing the work for the first course of masonry.

The construction, properly so-called, was undertaken in 1869. The galvanized wrought-iron gudgeons, 0.06 meter square and 1 meter in length, were fixed in the holes, and the masonry was commenced with small undressed stone and Parker-Medina cement. In fact, a cement of the most rapidly hardening character was essential, for the work was carried on in the midst of waves breaking over the rock, and which sometimes wrenched from the hand of the workman the stone he was about to lay. An experienced sailor, with his back against one of the iron stanchions, was always on the watch to give warning of such waves as were likely to sweep the rock, when the men would hold on, head to the sea, while it washed over them. On the other hand, when he announced a probable calm, the work went on with great rapidity. All the workmen were supplied with life-belts, as the fishermen had been, as well as with spikes, to prevent slipping. The conductor also, and the engineer, who by his presence alway encouraged the workmen, were similarly furnished.

When a landing was practicable the stones and small bags of cement were landed by hand, and care was taken to dress the surface of the masonry before commencing a new course. It is unnecessary to add that the cement was employed pure, and mixed with sea-water.

At the close of the season of 1869, 25 cubic meters of masonry had been executed, and these were found intact the following year.

At the present date the cubic contents of the masonry are 454.85 meters, rising to a level of 2.60 meters above the highest tides. The success of the undertaking may therefore be looked upon as assured, and at this stage the work may be expected to advance more rapidly.

Since 1871 Portland cement was substituted for Parker, the resistance of the former to the decomposing action of sea-water being ascertained to be superior to that of the latter; and the stone work at the foot of the building will be preserved by refilling the interstices, and perhaps by a continuous covering of the same material.

According to the project recently adopted, the light will be of the second order, with a flashing light, and the focus will be elevated 28 meters above the level of the highest tides. This limit might have been exceeded, so as to admit of a light of the first order, but for the insufficiency of the base, and it was necessary above all things to insure the stability of the edifice. The part constituting the basement will be continued with the diameter of 7.20 meters up to the level of high tides, and with that of 6.90 meters for the three following meters. The limited extent of the rock necessitates these small dimensions. The interior diameter will vary from 3 meters in the lower to 3.40 meters in the upper part, by means of successive offsets, and the thickness of the wall will diminish from 1.70 meters level with the entrance door to 0.80 meters below the cornice of the capping. There will be eight stories in the edifice, one of which will be devoted to a sounding apparatus to indicate the position of the light-house during a fog.

The annexed table, while reproducing some of the figures already given, shows the principal facts relating to the works executed, commencing from 1867:

Years.	Number of landings.	Number of hours on rock.	Cube of masonry executed per year.	Cube of masonry executed per landing.	Cost per year.	Average cost per cubic meter.
		h. m.	*Meters.*	*Meters.*	*Francs.*	*Francs.*
1867	7	8 00	.....	.....	8,000	.....
1868	16	18 00	.....	.....	21,000	.....
1869	24	42 10	25.05	1.04	25,000	998
1870	8	18 05	11.55	1.44	26,336	2,289
1871	12	22 10	23.40	1.95	17,000	721
1872	13	34.20	54.65	4.20	40,000	727
1873	6	15 25	22.00	3.67	62,000	2,818
1874	18	60 10	115.30	6.41	71,800	623
1875	23	111 55	203.00	8.80	76,000	375
Totals	127	329 15	454.85	4.37	347,136	745

This work was conceived and planned in what is essential by M. Léonce Reynaud, director of light-house service. In the first instance, it was carried on under the direction of M. Planchat, engineer in-chief, and afterwards under that of M. Fénoux, engineer-in-chief; by MM. Ioly, from 1867 to 1878, Cahen, from 1869 to 1874, and Mengin from 1875. MM. Lacroix, principal conducteur, and Probesteau, conducteur, have been successively charged with the superintendence of the works.

It is to be regretted, since it would only be an act of simple justice, that to this list cannot be added the names of those brave sailors and Breton workmen who, unconscious of their claims to admiration, have, by dint of energy and earnestness of purpose, insured the success of an enterprise bolder and, it might be said, more rash than any preceding undertaking of the same nature.

Light-house of the Roches-Douvres.

[Drawings on scales of 0.01 and 0.04 meter.]

The plateau of the Roches-Douvres is the most northerly of these innumerable reefs that render navigation so dangerous on the coasts of Bretagne. It is nearly equidistant between the islands of Bréhat and Guernsey, and 27 nautical miles from the offing of the harbor of Portrieux.

The necessity of erecting a light-house on this point had long been recognized, but the construction of a lofty stone tower in a part where the sea, owing to the great force of the tide-currents, is constantly rough, was likely to present many difficulties, and consequently to involve a considerable outlay, especially as sailing vessels only were available for the service, and these might frequently make fruitless voyages, on account of being compelled to cross the currents, both in

going and returning. Steam navigation and the use of iron for purposes of construction appeared to set these questions at rest, and in the sitting of the 24th January, 1862, the Light-House Commission decided to illuminate the Roches-Douvres by a revolving light of the first order.

The rock upon which it is established is situated near the middle of the south side of the plateau. It rises to the level of flood-tides, and the stone basement of the edifice is 2.10 meters in height. The iron tower is 48.30 meters from the foot to the level of the upper platform, and 56.15 meters to the summit of the lantern. Its diameter, which is 11.10 meters at the base for the inscribed circle, diminishes to 4 meters at the top.

The focus of the lighting apparatus is 53 meters above the level of the highest tides.

Cast-iron stairs occupy the center of the building; the storerooms and keeper's lodgings are situated in the lower part, and are surmounted by two interior galleries into which shipwrecked persons can be received, and where the workmen can sleep, when exceptional circumstances necessitate their passing some days in the light-house.

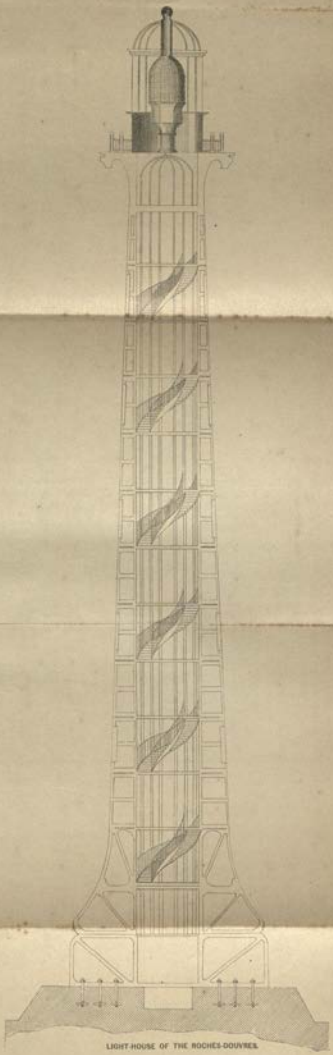
Up to the present time the majority of iron light-houses have been constructed with plates of iron more or less thick, riveted together; but in the present instance it was not thought expedient to adopt this plan, in the first place, because it causes the stability of the edifice to depend upon a covering greatly exposed to oxidation, and on this account it is deficient in the requisite conditions of durability, especially if neglected; in the second place, because the riveting and mode of construction require special workmen, and also because the scaffolding necessary is difficult to erect upon a rock of limited dimensions. The following conditions were therefore observed:

1. To render the skeleton of the edifice entirely independent of the exterior covering; to shelter it from the sea-fogs which rapidly cause oxidation; to facilitate inspection and proper keeping, and to reduce as much as possible the extent of surface exposed to humidity.

2. To manage the process of construction in such a way that the tower should be erected without scaffolding at the bottom, and without clinching a single rivet on the place.

Stress was also laid upon the necessity of the parts being of such dimensions as to obviate any difficulties of embarkation, of stowage on board, and of placing in position.

Sixteen great uprights or standards, each consisting of fifteen panels in the height, constitute the skeleton or frame-work of the building. Each panel is in simple T-irons, put together, consolidated, and riveted in such a manner as to insure the most perfect solidarity and resistance to deformation, contingent upon the strongest shocks or pressures that could be foreseen. These panels are bolted one upon another, and cross-braces, inside as well as outside, also bolted, keep the standards



LIGHT-HOUSE OF THE ROCHES-DOUVRES.

in position. Finally, on the last cross-braces and on the exterior surfaces of the standards are fitted sheets of iron, constituting a covering, the joints of which are protected by wrought-iron plate bands fixed by bolts. Each standard is surmounted by a cast-iron bracket, on which is corbeled out the platform required for the external service of the lantern. The standards rest upon a large cast-iron foot-plate held by six wrought-iron bolts, and embedded in a solid mass of concrete.

The chambers are surrounded by a brick wall, which, for effectual shelter, is $0^m.05$ from the sheet-iron tower; they have also brick partitions. A floor in concrete raises the surface to $0^m.40$ above the cast-iron foot-plate, while the ceiling is in stone work resting on small iron joists.

The service chamber is at the top of the tower, and communicates with the lantern by a cast-iron stepladder as usual.

The stairs of the tower are in cast iron with wrought-iron stringers. The outer stringer is bolted to the standards where it meets them, and thus contributes to the rigidity of the system. A half turn of the stairs corresponds exactly with the height of a panel, that is to say, $3^m.20$.

The door of entrance is in oak, with bronze mountings, and all the window frames are in rolled iron.

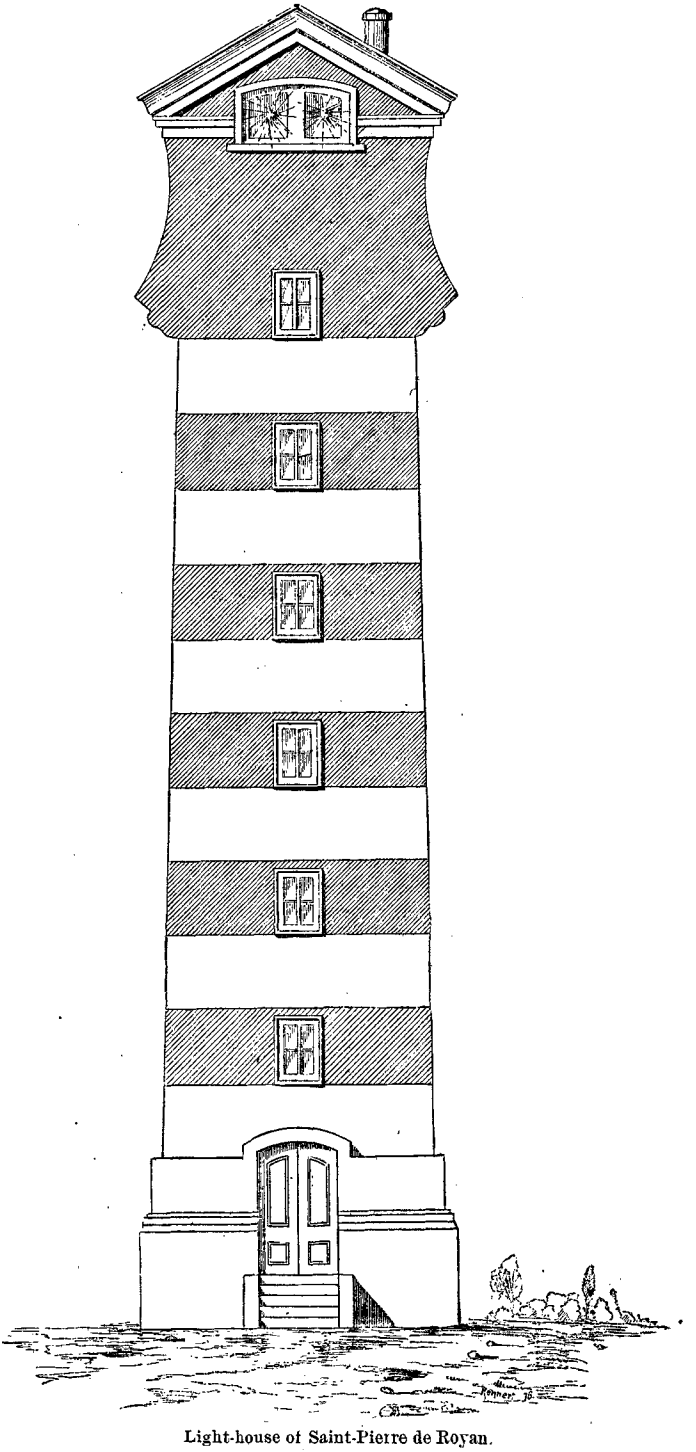
	Francs.
Iron tower, properly so called, wrought iron and castings, 317,328 kilograms	223,986.76
Joiner and locksmith work, bronze handrail, and painting	33,788.57
Lantern, lighting apparatus, fog-bell	85,576.21
Packing and carriage	19,819.81
Locks, apparatus for erection, various fittings	17,086.02
Foundation work and construction	225,100.00
Total	605,357.37

The engineers for the iron tower were MM. Léonce Reynaud, inspector-general "des Ponts et Chaussées," director of the light-house service, and Émile Allard, engineer-in-chief "des Ponts et Chaussées"; constructor, M. Rigolet, of Paris. The engineers for the foundation works and the construction on the rock were MM. Dujardin and Pelaud, engineers-in-chief; de la Tribonnière, resident engineer; Bertin, "conducteur des Ponts et Chaussées," and La Bozec, "employé des Ponts et Chaussées."

Light-house of Saint-Pierre de Royan.

(Drawings on a scale of $0^m.04$.)

The embouchure of the Gironde presents two distinct passages, tending eastward in directions nearly at right angles to each other. The northern passage is wide and deep, and most used by vessels; the other, the southern passage, though less practicable for navigation, offers great advantages, even for ships of large tonnage, when vessels enter it with the wind in the south and at the turn of the flood tide.



Light-house of Saint-Pierre de Royan.

The two light-houses of Saint-Pierre de Royan and du Chay, distant from each other 2 kilometers, are intended to light the passage, and to replace advantageously, on the right bank of the river, two of the old beacons, which were only useful during daylight. In order that no confusion might occur in these arrangements for the safe navigation of the embouchure, which was already provided with a great number of lights, the two light-houses in question only illuminate an angular and limited space. The apparatus is placed in the upper chambers of the edifices, in front of windows opening in the direction of this passage, and consists of spherical reflectors which throw back the luminous rays from the focus upon lenses *à échelons*, of which the parallel optical axes are situated in the vertical plane of the line of direction required.

There is only one apparatus in the light-house du Chay, while there are two in that of Saint-Pierre, on account of the greater distance of the tower; all these lights are red and fixed.

The edifices consist of stone towers, of a rectangular form, and the interior arrangements are the same. The most important is that of Saint-Pierre.

The plan of this building is that of a perfect square, the measurement of which is 5^m throughout the whole height of tower. This edifice is intended to serve as a landmark during the day, and to render it more clearly visible. and obviate at the same time the possibility of confounding it with the steeples of the town of Royan, the upper part has been enlarged by means of wing walls, corbeled out $1^m.50$ on each side. In addition to this, it is covered with broad horizontal bands, alternately red and white. The signal on the top of the tower stands out against the sky, and is painted entirely red. This light was kindled on the 15th June, 1873.

The plans were drawn up by M. Reynaud, inspector-general, by M. Lasne, resident engineer, under the direction of M. Marchegay, engineer-in-chief. The works were conducted by M. Sauvoin, "conducteur des Ponts et Chaussées."

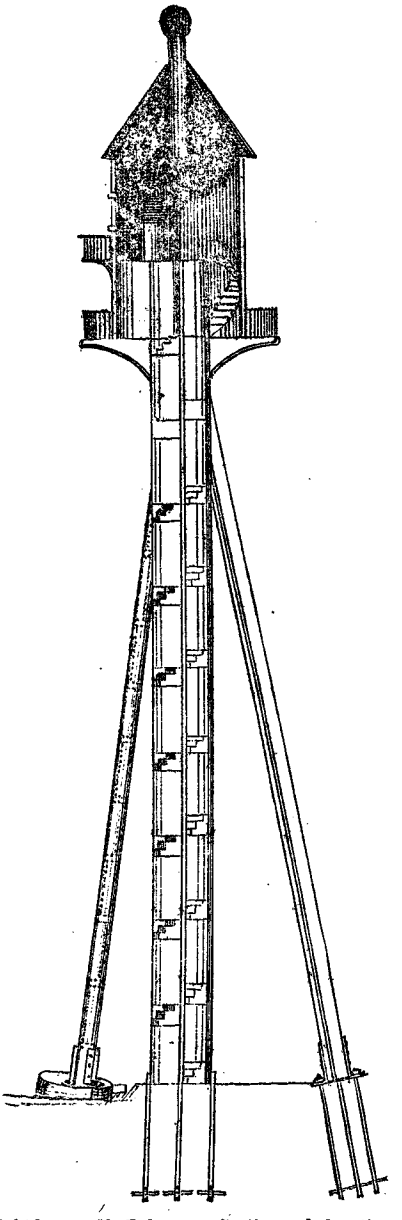
Light-house of la Palmyre.

(Drawings on scales of $0^m.02$, $0^m.04$, and $0^m.20$.)

Tower and dependencies.—The light-house of la Palmyre is situated in the middle of the downs on the right bank of the Gironde, and 5 miles inland from the point of la Coubre. Concurrently with the light-house established on this point, it is intended to point out the first line of direction at the entrance of the northern passage of the embouchure of the river, also to enable vessels to avoid the bank of la Mauvaise, of which the slow and steady progress north-northeast has led to an alteration in the line of beacons formerly placed in this passage, and which has become dangerous.

It was not considered expedient for various reasons to erect a build-

ing of stone in this place. It was therefore decided to erect an iron tower, after a new system invented by M. Lecointre, engineer de la marine and of the Mediterranean Company of Forges and Workshops.



Light-house of la Palmyre. Section and elevation.

The shaft of the tower consists of nine cylindrical tubes, each $2^{m}.80$ in height, fitted one upon the other, and forming a staircase 2^{m} in the interior diameter.

The nine tubes form a pillar 25m.20 in height, having a solidarity with the foundation, which consists of concrete 3m in thickness, run into the sand of the down on which the light-house stands. The tube is connected with the foundation, both at the top and at the base. For this purpose, flanged cast-iron shields or plates, imbedded in the lower part of the concrete, serve as points of holding for bolts, which traverse the whole thickness of the foundation. The heads of these bolts are fixed in the plates on the one part, at the base of the first lower tube, by riveting, and held on the other part by a double system of screw nuts. This plan of connecting the base of the tower with its foundation is also employed to attach the two upper tubes of the column to the same solid mass. With this view, two tubular iron struts are riveted by means of elliptic angle-irons to the eighth and ninth tubes, and are fixed to the plates in the same manner as those that sustain the column.

The plane of the mass of concrete is in the form of an equilateral Y, of which each branch is 4m in breadth, and is terminated by a semicircle, having its center at 5m from the axis of the tower. The central pillar is maintained in position by six bolts 0m.07 in diameter and 3m.67 in length, and rests upon a vertical monolith socle 0m.40 in height. The axis of each of the three struts meets the surface of the concrete in the center of the circumference which terminates each branch of the Y. These struts are fixed at their base to 4-foot plates, by means of a similar number of bolts, 0cm.07 in diameter and 3m.67 in length, held in the same manner as those of the center by cast-iron plates. These 4-foot plates rest on a cylindrical socle, forming one with the solid concrete, and of which the surface is perpendicular to the direction of the strut. The foundation bolts are respectively parallel to the struts which they fasten. The cylindrical lengths of the struts and of the newel of the stairs are jointed to each other, so that the upper extremity of each division is covered for about 0m.10 of its length by the lower portion of the part surmounting it, and these junctions are secured by rivets.

The cost amounted to the sum of 134,268 francs 55 centimes, divided as follows:

	Francs.
Road of access	27,752.38
Foundations, keeper's house, and out-buildings	29,935.37
Iron tower	76,580.80
Total	134,268.55

TURRET AND CANDELABRUM FOR PORT LIGHTS.

(Two models on a scale of $\frac{1}{10}$.)

THE TURRET.

The arrangements of this turret are such as to realize a mode of construction at once simple and economical, and offering at the same time great facilities for transport and erection. It rests upon a cast-iron

plate in a simple piece, and is attached by five bolts either to the masonry or to the frame-work of a jetty. It consists of a riveted sheet-iron cylinder, with striated sheet-iron stairs inside, supported by a cast-iron pillar or newel, and riveted to the cylinder by means of angle-irons. The cylinder and stairs form one, and are taken to pieces. The length does not exceed the limit specified in the railway tariffs of carriage, and is easy to manage and raise by means of a winch. Cast-iron flanges and brackets, bolted to the cylinder, support an open-work cast-iron gallery, with a wrought-iron balustrade, and a cylindrical sheet-iron cylinder, which carries the lantern. These complete the turret, properly so called.

The lantern is in bronze, it has cylindrical glasses, and is surmounted by a copper cupola. At the base of the candelabrum, upon which is placed the apparatus for lighting, a revolving cast-iron landing-place enables the keeper to clean the glasses without obstructing the passage of the stairs.

The cylinders being placed in position by means of a winch, the other parts, which are comparatively light, are easily raised by a tackle suspended from a beam projecting from the top, and firmly attached to it by ropes. The weight of the turret proper, the foundation plate and upper part, is about 6,500 kilograms. The cost of the construction, including the lantern, glasses, and candelabrum supporting the apparatus for lighting, is 9,200 francs in Paris.

THE CANDELABRUM.

The candelabrum enables a port light to be placed at the extremity of a very narrow jetty, where it can be hoisted to a height of 8^m during the night, and locked up in a sheet-iron cabin during the day, till the moment of lighting. This cabin bears two uprights in sheet iron, at the top of which is fixed a pulley mounted in a cast-iron block.

Two half-round wrought-iron guide rods are held at the top by the side of the uprights by two iron arms, and at the bottom by a table in sheet and wrought iron, which projects outside the cabin. The apparatus is rolled onto this outer table when it is necessary to hoist it, and is provided with ears, which run on the iron guides during its ascent.

The front of the cabin facing the service table and the guides is pierced with an aperture sufficiently large to admit the lantern, and is closed by two shutters opening inwards. Above this aperture, and inside the cabin, is the little cast-iron winch, with brake, round which winds the chain for hoisting.

An interior table receives the apparatus when not in use, and is terminated by a cast-iron turning table or plateau intended to facilitate cleaning. The opposite side of the cabin is pierced by an aperature, with a door fastening with lock and key.

The interior is lighted by two lateral windows, and by a round hole pierced in the roof, and glazed. This allows the ascent of the lantern to be watched, and also to be assured that it is lighted.

The weight of the cabin is about 1,000 kilograms, and the price, all accessories included, 1,680 francs in Paris.

These two little constructions have been adopted by the light-house board of direction. They were invented and are manufactured by M. L. Sautter, Lemonnier & Co.

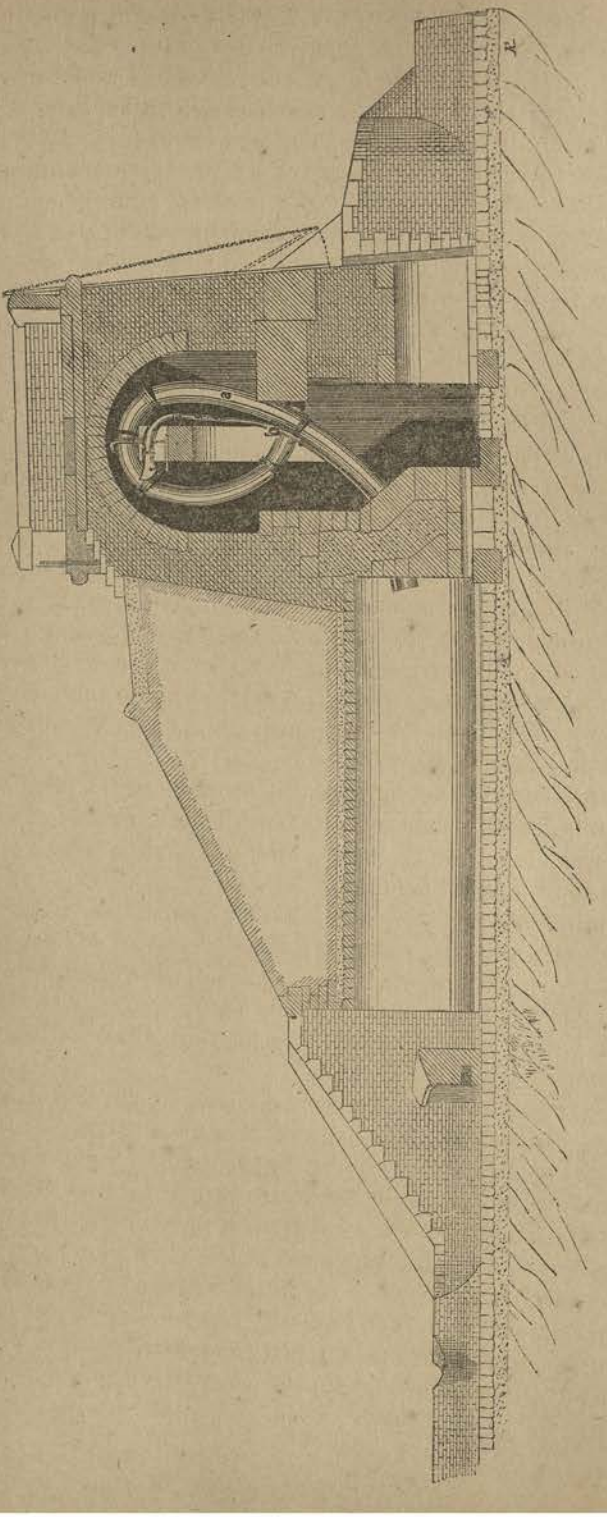
DAM AND SIPHON WEIR OF THE RESERVOIR METTERSHEIM.

CANAL OF THE COAL MINES OF THE SARRE.

The reservoir of Mittershiem supplies part of the canal of the Sarre coal mines, and is formed by a barrage in the valley of Naubach, where it constitutes a reserve of water having a surface of 261 hectares, and a maximum depth of $8^m.10$ above the bottom sluice. Its total capacity is 7,000,000 cubic meters, and of this quantity, 5,800,000 (equal to a volume of water $3^m.46$) can be appropriated to the supply of the canal. Local circumstances require that the regulation level of the reserve should not be appreciably exceeded, and to insure the perfect working of the weir, it has been necessary to reduce this limit to $0^m.05$.

Dam.—The dam is $332^m.50$ in total length, $8^m.82$ in depth from the capping to the bottom plug or sluice, 6^m in breadth at the top, and attains a maximum breadth of $36^m.80$ at the base, in the bottom of the valley.

Siphon weir.—The regulating apparatus consists of two large cast-iron siphons, $0^m.70$ in interior diameter and $0^m.022$ in thickness, communicating by their ascending branch with the reservoir at $3^m.50$ below the reserve, and by their descending branch, with a discharge canal in which their orifice is kept under water by means of a small barrage. A small tube, $0^m.15$ in diameter is joined to each siphon and follows it throughout the whole of the bend. The lower orifice of this tube discharges into the same canal in which the end is also submerged, while the upper orifice opens into the reservoir exactly on a level with the reserve. This tube serves as a fetching tube (*amorceur*) for the siphon, and both are in permanent communication by means of a bent pipe, which connects their most elevated points. The head of the fetching tube is in cast iron, and is enlarged in the shape of a bell, expanding horizontally to an arc of a circle with a radius of $0^m.80$. The two sides or lips (*lèvres*) of this head are profiled in such a manner that the lower lip presents to the water a horizontal line of overfall placed exactly at the normal level of the reserve. The upper lip is terminated by a rounded surface, tangent in its whole development to a horizontal plane passing at $0^m.005$ above the lower lip. From these arrangements it results that the orifice of entrance is only submerged when



Dam and siphon weir of the reservoir at Mettersheim. *a*, Siphon. *b*, Fetching tube (*amoreeur*).

the level of the rises to more than 0m.005 above the regulation reserve. The fetching (*amorcement*) is then effected in the following manner:

As soon as the water rises above the regulation reserve, it flows over the lower lip of the fetching tube; if this elevation attains 0m.005 the entrance orifice of the fetching tube is submerged, and from that time the air contained in the fetching tube, in the siphon, and in the upper tube ceases to be in communication with the atmosphere. Then the water, in overflowing, draws the air from the small tubes and exhausts that of the siphon, and there ensues a diminution of pressure in the interior of the apparatus, the water ascends into the siphon, the fetching takes place, and finally the siphon works with increasing speed and discharge.

But another phenomenon prevents the pressure from indefinitely diminishing, and the delivery from indefinitely augmenting. The increasing velocity of the water entering the fetching tube creates, near its head, a partial depression in the plane of the fluid; this depression deepens in proportion to the augmentation of speed, and at last reaches and uncovers the upper lip of the orifice, thereby causing the admission of a certain quantity of air into the apparatus, a consequent increase of interior pressure, and a diminution of speed. The same facts being successively produced, there results from these two opposing tendencies a series of oscillations corresponding to the shutting and liberating the upper lip of the fetching tube. This state of agitation soon ceases, and a steady movement is established, during which there is a simultaneous issue of water and air.

When the rising of the water ceases the level of the reservoir lowers, and the same phenomena are produced in an inverse direction; the siphon action stops, and the flow is arrested when the plane of the water returns it to its normal height.

A few millimeters of elevation in the plane of the water above the fetching tube suffice to cause a marked increase of speed. The air ceases to enter and the water escapes from the filled tube before this elevation has attained the permissible limit, 0m.05. The discharge is then 0m.60 per second, a quantity greater than the maximum delivery of the risings.

In order to exercise complete control over the apparatus, the head of the fetching tube has been disposed in such a manner that it can be raised or lowered in a single piece, by the aid of a regulating screw, the impermeability of the communications being assured by free dilatation joints. In addition, a small vertical iron valve gate has been placed in the head of the fetching tube, and it can move round a vertical axis, without ceasing to fit closely to the interior of the two lips, which allows the entrance aperture and consequently the discharge to be varied. The regulating is effected once for all, and the apparatus afterwards works automatically and requires no supervision.

The apparatus is double, and consists of two siphons, each of which is furnished with its own fetching tube, with tube of communication. Thus each siphon forms a complete system, capable of working by itself while the other may require to be examined, repaired, or regulated.

The idea of employing fixed siphons as weirs for the regulation of a reserve was proposed by M. Girard and applied to the Southern Canal; but large siphons have been employed there, which required considerable variations in the level of the reserve, to put them in motion or to stop them. The peculiar conditions existing at Mettersheim and the very restrained limit permissible, $0^{m}.05$, led M. Hirsch, engineer "des Ponts et Chaussées," to invent the special system of fetching tubes, which has completely fulfilled the purpose for which it was intended.

Water was let into the reservoir in December, 1866, and the siphons were put in action, for the first time, on the 12th January following.

SAINT LOUIS CANAL.

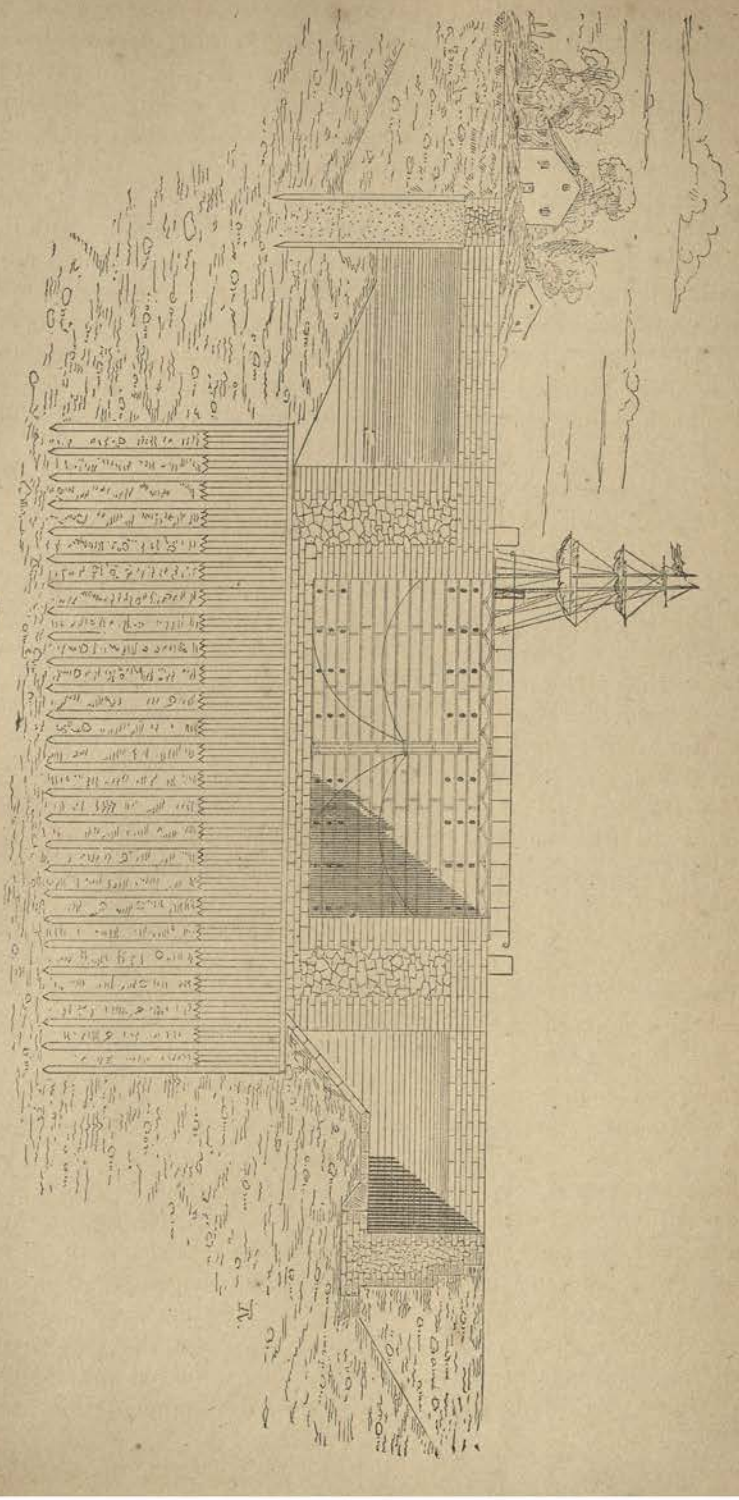
IMPROVEMENT OF THE EMBOUCHURES OF THE RHONE.

(Drawings.)

Numerous attempts have been made to lower the bar of the Rhone, where this river discharges its waters into the Mediterranean, but hitherto they have resulted in failure. It was therefore decided to open a direct communication between the Gulf of Foz and the deep part of the river, above the bar, by means of a canal designated the "Saint Louis Canal."

This canal begins on the left bank of the Rhone, at the commencement of the dike constructed in 1856, for the enbankment of the Bras de l'Est (Eastern Arm), at a distance of 600 meters below the Tour Saint Louis, and taking a straight line from west to east, it terminates in the Gulf of Foz, opposite the port of Bouc. At the Rhone end it is closed by a lock, while at the sea it discharges into a port formed by two jetties. On the canal side of the lock a basin has been excavated to enable vessels to turn round, in order to pass from the lock into the canal, and *vice versa*.

The Saint Louis Canal having been established as a substitute for the natural embouchure of the Rhone, it was necessary to create a depth of water exceeding that of the river itself below the port of Arles. Between Arles and Saint Louis the depth of water is scarcely 2 meters, and even with the improvements now being made it does not appear probable that more than 4 meters will ever be obtained, in consequence of the reefs of hard pudding-stone encountered at certain points in the bed of the river. A depth of 4 meters was therefore considered sufficient for the mouth of the canal. But the idea presented itself that, the entrance of the Rhone once rendered practicable, the river traffic would immediately take such a development that it would



Saint Louis Canal.—Rhone end.

be absolutely necessary to secure the possibility of putting it into communication with the maritime navigation. For this reason, the Government decided to give a depth of 5 meters to the Saint Louis Canal. For a maritime channel of such dimensions, it was essential to create a port on the Rhone capable of receiving vessels coming from the sea by the canal. This port was formed at Saint Louis itself; the basin was enlarged sufficiently to admit of the necessary maneuvers of vessels; quays were built, and at the present moment others are in course of construction on the Rhone, just above the outlet of the canal.

The canal properly so called is 3,330 meters in length from its entrance into the basin at one end to the sea-shore at the other. It is 6 meters in depth below the level of low tides. The width at the bottom is 30 meters, and at the level of low tides 63 meters.

On each side of the canal a towing path has been formed, 12 meters in breadth, with a level of 2 meters above the water.

Along the whole length of the towing paths the earth excavated from the canal was put in depots or spoil-banks, and these have been kept $2^{m}.50$ above water level in such a manner as to be above the highest level of the waters of the Rhone, and to protect the canal in case of inundation. The basin is 400 meters in length by 300 in width.

Quay walls have been built on three sides, and the length finished up to the present time is 850 meters. This length will attain 1,100 meters when the walls in course of construction are terminated on the western, northern, and eastern sides. The capping of the quays is established $2^{m}.50$ above water level, and the earth platforms behind are made flush to the same height.

The works of the canal and basin were executed dry, by the aid of two coffer-dams—one at the sea end, the other in the excavations for the lock. A third coffer-dam was formed about half way between the two, in order to provide against the contingency of either of the end dams giving way. They were made partly with the natural soil and partly with the clayey ground taken from the cuttings.

The draining was accomplished by means of rotary pumps (Neut and Dumont), worked by a portable engine. There was a pumping shaft for each of the divisions into which the canal and basin were separated by the center coffer-dam, in which last auxiliary pumping machinery was established. Each shaft was furnished with two rotary pumps, and two portable engines of 8 to 10 horse-power.

The port is formed by two jetties, of which the southern one is parallel to the axis of the canal at a distance of $48^{m}.25$ from the axis; it advances as far as the natural bottom of $6^{m}.50$, and is $1{,}746^{m}.20$ in length. The other commences 1,350 meters to the north of the canal; it has only advanced as far as the natural bottom of $3^{m}.25$ and is at present but 500 meters in length. Being perpendicular to the direction of the bank, it tends towards the wing wall of the northern jetty in such a manner that if the two jetties should be carried out on a straight line

to a depth of 7m.5, there would remain a passage 200 meters in width between the wing walls.

The jetties are constructed exclusively of rough stone, or the natural rock.

The northern jetty is only 1m.25 above the level of low tides, and is 4m broad at the top. It is built of stones of an average weight of 50 kilograms, and the talus are faced with stones of 300 kilograms.

The southern jetty is elevated 2m.50 above the water level. It has 0m.20 more convexity, and its breadth at the top is 2m. It is formed of stone of 50 kilograms, average weight. The facing of the northern talus is of stones of 300 kilograms, and that of the southern side of blocks weighing at least 500 kilograms. For the wing wall, terminating the southern jetty, and which is about 20m in diameter at the top, the facing is composed of blocks of 1,200 kilograms in weight.

Above the level of low tides the rough stone work that forms the facing has been carefully laid by hand, and tightened by stone splinters in form of wedges. At the level of the water, on each side of the southern jetty, a course of large stones and blocks has been laid to prevent the slipping of the lower part of the talus, and the facings are thus kept in repair from the top of the jetty.

The inclination of the talus is 2 of base for 1 of height.

The works of the canal, commenced in 1864, were only terminated at the end of 1873.

The locks will give passage to vessels requiring to enter the Rhone from the sea, and also to boats coming from the Rhone to the canal. The dimensions have been calculated as follows:

	Meters.
Width between side walls	22.00
Depth of water in center at low tide	7.50
Working length of chamber	160.00
Total length of work	184.50
Depth of water on sill	7.50
Depth of water in the canal	6.00

The lock is inclined down stream from the river on an angle of 14° 2′ 10″. It is provided with two pairs of gates, and the versed sine of the sills is one-sixth of the breadth of the lock.

The eastern quay wall of the channel entering the Rhone is formed, like those of the basin, directly on the soil. The western quay wall, the wing wall of the lock, and the quay of the Rhone are constructed of solid masses of beton run into the inclosure.

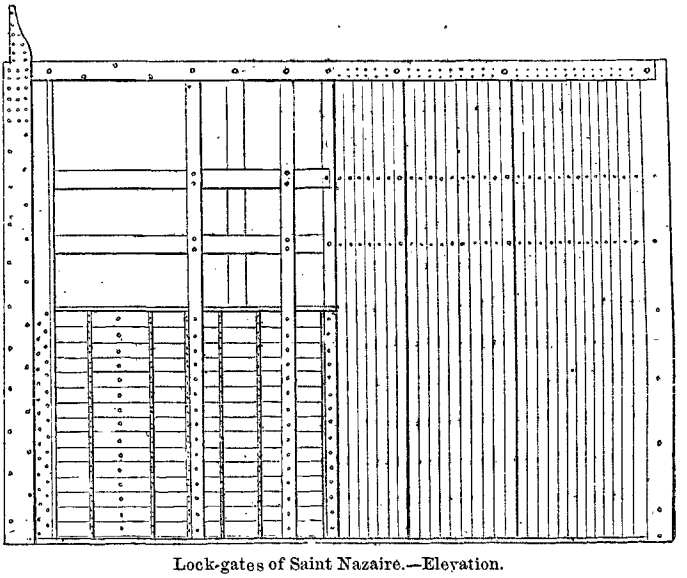
The lock and its retaining walls, and the eastern quay wall of the channel, were built entirely dry, by means of a coffer-dam formed by the natural ground left intact along the Rhone, with a breadth of a few meters. A similar dam separated the excavations of the lock from those of the basin, so that in case of accident or rupture of the Rhone coffer-dam the basin would be protected from the water.

The cost of the canal and port of Saint Louis, including the supplementary works, will amount to 15,400,000 francs, divided as follows:

	Francs.
1. Canal, basin, and port	10,053,000.00
2. Lock	3,741,649.74
3. Lock-gates	174,496.74
4. Beacon of south jetty	23,900.00
5. Embankment of Eysselle	25,742.98
6. Quays on the Rhone	684,206.13
7. General expenses (about)	697,004.41
Total	15,400,000.00

LOCK GATES OF SAINT NAZAIRE (LOIRE INFÉRIEURE).

(Model and drawing.)



Lock-gates of Saint Nazaire.—Elevation.

The port of Saint Nazaire has two locks 25 meters in width. The first puts the basin into communication with the roadstead, and is furnished with two pairs of wooden gates; the second will subsequently connect the basin of Saint Nazaire with that of Penhouet, now in course of construction, and has one pair of iron gates. This lock is temporarily used as a graving dock. The maximum pressure supported by the two pairs of wooden gates is 6 meters, which corresponds to the difference between flood and ebb of equinoctial spring tides.

At strong tides, when the graving dock is dry, the iron gates have to support a pressure of 10 meters of water. This difference necessitated giving them great power of resistance. As there is no appreciable difference between the dimensions of these gates in respect to height and breadth, a comparison between the two systems may possess some interest.

§ I.—*Cross-gates.*

Principal dimensions.—The lock of the port of Saint Nazaire has an opening of 25 meters, and each of the leaves is $15^{m}.96$ in total breadth, and 10 meters in height. The thickness at the principal post is $0^{m}.60$, and at the middle $1^{m}.60$. The tail face is flat, and the head face is curved to an arc of a circle concentric to one passing through the interior angle of the chief posts and the extremity of the miter sill.

The real novelty presented by the gates of Saint Nazaire is the absence of heel and miter posts. Special and expensive woods are therefore no longer necessary for the construction of gates having great width of opening and a considerable depth of water; neither is there reason to fear the dislocation which causes the destruction of all gates. Wood of a resinous nature and of ordinary dimensions is all that is required.

The idea of vertical bonds, obtained by means of interior keys or ties to the leaves, appears also excellent, but it had been previously applied to gates having an opening of $16^{m}.50$. The gates constructed in 1856 were made entirely of Prussian pine, while those of 1858 were in pitch pine. Since their erection they have worked without accident or the least dislocation.

§ II.—*Iron gates of the lock of Penhouet (temporarily utilized as a graving dock).*

Principal dimensions.—These gates have the same form and principal dimensions as the wooden gates previously described, almost the only difference being that their height is $10^{m}.25$ instead of 10^{m}.

Composition of gates.—Each leaf consists of twelve cross-pieces, three vertical girders forming uprights, and two other vertical girders at the extremities constituting heel post and miter post.

Ballast.—Each leaf weighs 140 tons in the air, and as it would float in the water, before being completely submerged, ballast is requisite, and for this purpose it is divided into two water-tight compartments by the fourth cross-piece, counting from the top.

The upper compartment serves as a receptacle for ballast, which is furnished by the water in which the gate is immersed. The water has free entrance and egress by the apertures in the up-stream and down-stream skin, so that the ballast is self-moving, and is proportioned in quantity and weight to the level of the water in the basin. The apertures are, however, fitted with valves, capable of being opened and shut at discretion from the foot-bridge, but, as a matter of fact, these valves always remain open. The lower compartment acts as a float, and remains constantly free from water. Water-tight tubes opening on the foot-bridge, and provided with fixed ladders in wrought iron, give access at all times to the upper compartment.

By means of the spontaneous action of the ballast, with a variation

of water level in the basin attaining to 1m.30 and in exceptional circumstances 1m.45 according to the tides, the actual weight of the gate with its ballast is maintained at between 10 and 12 tons.

Movable friction rollers.—Each gate has nevertheless been furnished with two rollers, which travel on circular iron ways let into the downstream flooring. These rollers can be taken up if necessary. They are set in a movable frame inside the gate, reaching above the second cross-piece, reckoning from the top. On this cross-piece is fixed a jack-screw, by means of which the frame and roller can be taken up at the same time.

To prevent the entrance of the water, the vertical supports of the frame pass through the lower and fourth cross-piece by the medium of a stuffing-box, and for greater security each frame is inclosed in a perfectly water-tight shaft. For the rest, the tubes that pass through the ballast-chest are amply sufficient to give access to every part of the float, if it were required to isolate them definitely.

Effects of oxidation.—The injurious effects of oxidation have been provided against, and upon this head it may be remarked that the gates can be frequently painted in the whole of the interior and on the plane surface. And, in addition to this circumstance, experience has shown at Saint Nazaire that the iron submerged in the basin is rapidly covered with a compact layer of shell-fish with calcareous coverings, named *cravants*. This casing has nearly the same preservative effect as a coat of paint.

SUMMARY COMPARISON BETWEEN THE TWO SYSTEMS.

In the course of this notice it has been remarked that, while the wooden gates constructed in 1858 were required to support a maximum pressure of 6m of water, the iron gates, owing to circumstances, were subjected to a pressure of 10m, and the results of this test have been satisfactory.

The cost price of each of the wooden leaves of the gates was 110,000 francs. The leaf of the same dimensions in iron cost 123,000 francs. This cannot be considered a very significant difference, regard being had to the constantly increasing price of timber of large dimensions.

If, in default of direct observations, the relative durability of vessels of iron and wood be taken into consideration, it may be inferred that, for sea-gates, as a question of economy, the preference must be awarded to iron rather than to wood, as the material of construction.

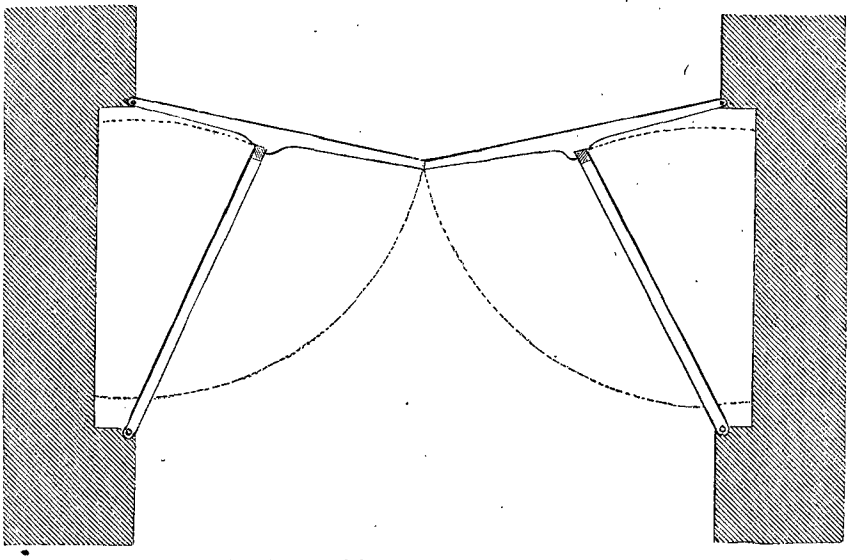
LOCK OF THE PORT OF DUNKERQUE.

(Model in stone, wood, iron, and bronze, representing the lock-gates and swing-bridge.)

Scale 0m.04 (one twenty-fifth).

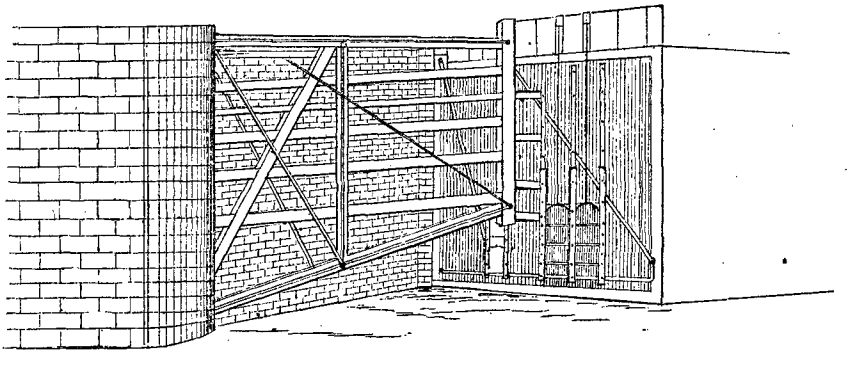
This lock, 21m in breadth, was not provided with a chamber, for the reason that it has to give passage to ships of the largest tonnage that

the capabilities of the port will permit; ships of which the draught allows them to enter only at high water. The lock is closed by a pair of ebb-gates abutted by *portes-valets*. Each leaf is provided with three



Lock-gates of the port of Dunkerque.—Plan.

wooden sluices, and worked by a rack and pinion-jack. The ebb-gates are worked by means of chains fastened to the faces of the miter-posts, and geared to winches on the respective banks. Small jack-screws,



Lock-gates of the port of Dunkerque.—Perspective view.

fixed to the return faces of the gate recesses, hold the miter-posts open, and prevent their displacement by the movement of the waves. The *portes-valets* are constructed on the same principle as ebb-gates.

The works of the lock were executed from 1856 to 1860. The total cost, without the swing-bridge, but including 160^{m} of quays to the ap-

proaches, amounted to the sum of 1,331,214 francs 39 centimes, thus divided:

	Francs.
Lock and walls of quay	1,257,623.54
Gates	67,316.40
Working machinery	6,274.35

The works were planned and executed by MM. Cuel and Decharme, engineers-in-chief, and Plocq, resident engineer, "des Ponts et Chaussées."

DETAILED GEOLOGICAL MAP OF FRANCE.

EXECUTED ON THE TOPOGRAPHICAL MAP OF THE STAFF, BY THE GEOLOGICAL MAP SERVICE.

The geological map service of France was instituted by a decree of October 1, 1868, with a view to the publication of a detailed geological representation of the country, upon the staff map on the $\frac{1}{80000}$.

For nearly two-thirds of the territory, the elements of this publication were already in existence, in the shape of departmental maps executed under the auspices of the general councils, at different periods since the year 1835. But these maps, executed and published on different scales and without any common plan, could neither be brought together for purposes of comparison, nor with the object of constituting one complete work. In addition to this, few of them showed any acquaintance with the recent progress of a science which during the last few years has received the most valuable accessions.

In 1868, the *personnel* of the service was placed under the superintendence of M. Élie de Beaumont, whose first efforts were directed to the study of the Parisian district, and it was soon ascertained that, whatever care might have been exercised in the previous surveys of this district, it was necessary to recommence in almost every part the detailed exploration of the ground.

For the documents composing a work of this magnitude, it was necessary to establish a methodical and uniform system of arrangement, capable of adequately meeting all the scientific and technical requirements that geology is called upon to satisfy; and this obligation, added to the necessity, before mentioned, of a new and more complete exploration, prevented the publication from being accomplished with the promptitude calculated upon at the commencement of the undertaking. In 1873, the work was not sufficiently advanced to allow of sending to the Universal Exhibition at Vienna more than twelve sheets, forming a rectangle, of which Paris occupied nearly the center, with their annexes, explanatory notices, longitudinal and vertical sections, photographic perspectives, &c. It should also be borne in mind that at this period there were many obstacles to be encountered. The limited number of the members of the service, all of whom had other special functions to perform, in addition to their geological duties; financial necessities,

defective organization of the service—all these circumstances concurred in retarding the progress of the work.

In 1874, a new arrangement of the service was necessitated by the death of the learned and illustrious man at the head of the work. The direction was confided to M. Jacquet, inspector-general of mines, and in the course of 1875, on the proposition of M. Caillaux, minister of public works, the National Assembly, justly impressed with the importance of the undertaking, did not hesitate to renew a grant by the aid of which the publication of from twelve to sixteen sheets per year may be expected, consequent upon the employment of an additional number of assistants, so that the completion of the work may be looked forward to in a period of from sixteen to twenty years.

The publication has hitherto been carried on at the National Printing Office.

DOCUMENTS EXHIBITED.

These comprise:

1. A central panel formed by the union of twelve sheets representing the extreme north of France, viz: No. 3 (Boulogne), 4 (Saint Omer), 5 (Lille), 6 (Montreuil), 7 (Arras), 3 (Douai), 11 (Abbeville), 12 (Amiens), 13 (Cambrai), 20 (Neufchâtel), 21 (Montdidier), 22 (Laon).

2. Two side panels with different specimens of sheets. The left-side panel contains, beside the title sheet and introduction, a longitudinal section carried across the Beauvois sheet, in a transverse direction to the axis of the district of Bray. Below is a copy of the Arras sheet, with the curves of the level of the ancient surface. The right-side panel comprises a trial sheet on the $\frac{1}{40000}$, relating to the outskirts of Paris, two sheets of vertical sections, one for Paris, the other for the environs of Beauvais, and two photographs of quarries, reproduced by the photoglyptic method, and in which the perspective has been arranged in accordance with the corresponding geological scale, by a geometrical diagram.

3. A longitudinal section on the $\frac{1}{80000}$ and $\frac{1}{100000}$ carried from north to south, across the Paris sheet, is figured below the three panels.

4. A special panel, comprising the Calais sheet, shows the results of the survey undertaken by two engineers of the geological service, MM. Potier and de Lapparent, with a view to the construction of the submarine tunnel between France and England. The croppings up of a strata of gault, glauconite chalk, and marly chalk, under the straits between Calais and Dover, are represented as shown by the boring operations. The existence of two dips has been remarked in the bearing of these croppings; one on the French and the other on the English side, between which no geological irregularity of importance is anticipated.

5. Map on the $\frac{1}{40000}$ of the southwestern district of the Morvan, environs of Saint-Honoré-les-Bains.

6 and 7. Enlarged photographs of eruptive rocks cut in thin plates.

Tableau No. 6 reproduces the granites, granulites, and pegmatites collected in France and in the Colorado. It indicates the analogy existing between the two granitic and granulitic series in Europe and America. Tableau No. 7 comprises porphyritic types principally collected in the Morvan.

MARITIME CANAL OF SUEZ.

The maritime canal of Suez was represented in the exhibition by the following maps, plans, photographs, &c. A large wall map in colored topography gives the Isthmus of Suez and the canal on a scale of $\frac{1}{200000}$. Large wall maps show the geological section and the profile of the work and give plans of Lake Timsah and the Harbor of Suez.

Ten photographs of large size show the harbor of Port Said; the manufacture of concrete blocks used in its construction; dredge-boats; locks of the Sweet Water Canal; the canal used in filling Lake Timsah; work-shops, and the peculiar dredge-boat used on the work, the "elevateurs," and the "drague à long couloir."

Ducher et Cie, publishers, Paris, exhibited a superb work on the Suez Canal, giving finely executed plates of all the machines, work-shops, and details of construction. About a third of the proposed publication was shown. The remainder is to be issued in parts.

The maritime canal of Suez joining the Mediterranean and Red Sea is about 99 miles in length from Port Said on the former to Suez on the latter sea. It is the largest ship-canal in the world, and the most important and expensive engineering feat of similar nature executed in modern times.

The line passes nearly north and south. Beginning at Port Said, the first great work was the construction of an entire harbor on the sandy shore, at a site, which was but an immense salt marsh covered to the depth of a few inches with the mingled waters of the Mediterranean and the Pelusiac branch of the Nile. The entire harbor was the work of the dredge-boats, and the entire site of the town has been constructed by using the material thus excavated. Two jetties form the harbor. The western one, 2,726 yards in length, extends at right-angles from the shore, the eastern one, 1,962 yards, converges to within 450 yards of the other, and the two inclose an area of 550 acres.

The piers are made of concrete blocks formed from the sand dredged from the harbor, mixed with hydraulic lime of Thiel in the proportion of 2 to 1. The blocks were 10.1 by 6.6 by 4.9 feet, or 13.08 cubic yards, and weighed about 22 tons each. They were made in work-yards of the harbor, and placed in position by means of barges. The piers are 26 yards at the base, 6 yards at the top, 12 yards high, with side slopes of 1 on 1. The total amount dredged from the harbor and its dependencies was 6,082,000 cubic yards. A powerful dredge has been constructed to keep the harbor clear, and especially at the entrance, where the operation is a difficult one in any but fair weather.

MEDITERRANEAN
SEA
PORT SAID
LAKE
MENZALEH
Gulf of Pelusium
MARITIME CANAL
OF
SUEZ
GREAT BASIN
of the BITTER LAKES
Gulf of Suez
RED SEA

To-day Port Said is a busy and well-constructed town, with commodious quays and wharves, warehouses and dwellings, the whole resting on made land. The town is supplied with fresh water from the Fresh Water Canal at Ismailia by an aqueduct 87,490 yards, or 49.1 miles in length.

From Port Said the canal passes nearly due south for some 13 miles through Lake Manzaleh. This is nothing but a sandy marsh covered with a few inches of brackish water, and separated from the Mediterranean only by a low sandy spit or neck.

In excavating through this and similar localities, it was feared that the banks of the canal would not be safe from the wash of the waves of passing steamers, and great care was taken to avoid this danger. A slope was made from the canal bank to the water edge, with an inclination of 1 on 10, and the waves passing up this natural beach lost their power of doing damage. To further the excavation and the disposition of the dredged materials in these situations, and indeed throughout the canal, two peculiar forms of dredge-boats were introduced.

The *dragues à long couloir* varied in length, the longest being 75 yards. Their shape is that of a semi-ellipse 5 feet wide and 2 feet deep. They are supported by a tall, iron framework, resting on the deck of a barge 97 feet long by 28 feet beam. The slope of the duct is inclined according to circumstances. The dredgings when dropped into the elevated end of this long duct are assisted in their downward progress by a strong current of water, and if necessary scrapers or sweepers also are used. With this assistance the dredgings were delivered over almost a horizontal line, and at a distance from the dredge which enabled it to work at almost any position in the canal. The semi-liquid materials thus discharged spread themselves over an extended surface, and thus became hardened and settled at a low angle. These dredges (twenty-two in number) averaged about 90,000 cubic yards a month, and one of them exceeded 130,000. When these machines were no longer available by reason of the elevation of the banks, recourse was had to the *élévateur*. In this the inclined plane extended upwards instead of downwards; was about 52 yards long, and carried two lines of tram rails. The inclination is 1 to 4, and the support is in the middle of an iron frame, which rests on a carriage running on rails laid for the purpose along the banks of the canal and 6 feet above the water line. The lower end of the *élévateur* reaches over the water, where it is again supported on a steam float. When at work the lower end is 3 yards above the water, and the upper end has an elevation of 12 yards, thus reaching over the embankments. A lighter containing seven boxes of dredgings is floated under the lower extremity of the *élévateur*. Each box is raised in succession to a truck, and then travels to the upper end of the incline. On reaching this point, the box swings vertically, the door opens automatically, and the contents are discharged, and the box is returned to the lighter.

At 42 miles from Port Said the canal passes through a cutting from 60 to 70 feet deep. This barrier was merely an extensive sand dune, and the work of removing it was easy in itself but expensive through the amount. The greater part of this work was done by hand, about 5,690,000 cubic yards having been removed before the machines were set to work.

Beyond this cutting the small lake, Timsah, was found to be below the level of the Mediterranean. It was successfully filled in two hundred and forty-seven days, and the volume of water thus necessary was 100,000,000 cubic yards. The lake has an area of about $7\frac{3}{4}$ square miles.

On its shores is located the town of Ismailia. This is connected by railroad with Cairo and Suez. At this point comes in the Fresh Water Canal, which it was found necessary to dig as a preliminary to the maritime one. It commenced near Cairo and led the waters of the Nile to Ismailia, 26 miles, and was then continued to Suez, 42 miles farther. Although built of sufficient dimensions to meet the ordinary requirements of an inland canal, the chief service has been to furnish fresh water to the towns along the line of the ship-canal, and without it, indeed, these could hardly exist. It was of immense value, during the construction, in furnishing a means of bringing supplies to the scene of work.

A second barrier of sand dunes found at Sérapéum necessitated extensive excavation, which at one time threatened serious trouble through the ledge of limestone found therein. Beyond Sérapéum the Bitter Lakes formed an immense basin below the level of the Mediterranean, and an area of 92 square miles demanded 1,891,865,000 cubic yards of water. This was safely done in 1869, and the waters of the two seas were brought together in this basin.

The third barrier, that of Chalouf, possessed additional difficulties in a bed of rock, requiring blasting, in the existence of hard clay with rocky nodules injurious to the dredges, and in its extreme length—8 miles—the depth being 62 feet. Thirteen million cubic yards were removed from this cutting by hand before the dredges were put to work. Beyond this part no serious difficulties were encountered until the construction of the harbor of Suez became necessary.

A basin dug from the dry land gives 19.7 feet of water at the entrance, and is inclosed by a jetty 4,600 feet in length and from 160 to 490 feet in width. A harbor and dock-room has thus been constructed suitable for the largest class of steamers. This harbor not being subjected to the waves and storms, which are very dangerous and troublesome at Port Said, is easily kept clear and in good order.

Work was commenced on the Suez Canal in April, 1859, and the opening ceremonies occurred in November, 1869. The total cost was $96,332,000.

It seems hardly necessary to allude to the immense saving in distance gained by the Suez Canal to commerce passing between Lon-

don or the Atlantic ports to India and China. From London to Bombay the distance saved is 9,832 miles, and from New York to Bombay 8,416 miles, over the route by the Cape of Good Hope. Since the day of opening the canal has been kept uninterruptedly open to the largest class of ocean steamers, and there have been no delays or accidents of any kind.

ITALY.

MAP SHOWING PLAN FOR THE AMELIORATION OF THE TIBER AND ROMAN CAMPAGNA PROPOSED BY GENERAL GARIBALDI AND PROFESSOR FILOPANTI.

The Tiber at present runs through Rome, and then by a tortuous course empties into the Mediterranean by two mouths.

Much of the country around Rome, called the Agro Romano, through which the river passes, is marshy, unhealthy, and half waste, though naturally very fertile, and in extent amounts to more than 1,000,000 acres. It is to reclaim this land that the improvement is proposed. It consists—

1st. In cutting a new channel around Rome through the hills to preserve the city from inundation. This will require the removal of about 25,000,000 cubic yards of earth.

2d. In rectifying the bed of the stream from Rome to near its mouth and there dividing it into two branches so as to drain the marshes.

3d. In making a canal from above Rome through the city, using the old bed of the stream restricted by quays, the flow of water being so regulated by gates as to have at all times a stream as large as the Seine at Paris available for navigation, irrigation, and motive power.

The canal divides below the city, one branch entering the rectified bed of the Tiber, which is to be made navigable; the other branch emptying into the Mediterranean above the mouth of the river, and to be used for drainage and irrigation.

A large basin is to be constructed at the mouth of the river and protected from winds by piers.

THE NETHERLANDS.

The Netherlands is one of the few countries which have made a special exhibit of engineering works.

The most prominent of these works are the river improvements, canals, and reclamation of lands. All these are finely shown by complete models and detailed drawings, and are described in the special catalogue of the Netherlands section and in "A sketch of the public works in the Netherlands, by L. C. Van Kerkwyk." These books were for gratutious

distribution, and the following notices on the Netherlands exhibit are condensed from them:

THE NEW RIVER FROM ROTTERDAM TO THE NORTH SEA.

There are exhibited a drawing, a model in relief showing the work as completed, and a model of one of the piers.

The different channels from Rotterdam to the North Sea becoming continually less practicable for navigation, the construction of a new one was an urgent necessity.

P. Caland, the present inspector of the hydraulic department, presented a project which was recommended for execution by a council of the hydraulic department in 1858, and comprises the improvement of the whole river from Krimpen to the sea along the northern arm of the Nieuwe Maas, named *het Scheur*, and the piercing of the corner of Holland.

By means of dikes and the clearing of some narrow places the river is brought to a normal width; the river *het Scheur* is dammed by a dike 569 yards long, and the river water is carried off by piercing the corner (*hoek*) of Holland, which piercing is widened into a river mouth by the working of the ebb and flow. This river mouth is continued to a sufficient depth into the sea by two dams, whilst dikes along these future bank lines, joining these dams, will limit the width of the river mouth.

The two dams in the sea are made of fagots covered with stones and fenced in by oak piles. The southern dam has, moreover, an oaken scaffolding to the height of 3¼ yards above the ordinary low-water mark. The top is defended by a palisade consisting of two or three rows of piles. This dam, upon which is raised an iron light-house, has a length of 2,004 yards and a crown width of 16¼ feet. The northern dam will have a length of 2,166 yards.

The work is now (September 1, 1875) so far advanced that in the most shallow part of the gully was measured 13 feet of water with ordinary low, and 18½ feet with ordinary high, water.

In the year 1875 there passed this canal 7,127 ships, measuring together 2,982,143 tons, besides 1,503 fishing boats, measuring together 105,537 tons. The cost of construction up to the year 1875 amounted to 10,000,000 guilders.

CANAL FROM AMSTERDAM TO THE NORTH SEA THROUGH THE ISTHMUS OF HOLLAND.

(Drawing and model in relief.)

This canal, having a width on the water surface varying from 141 to 65 yards, is constructed to establish a regular communication between the North Sea, and Zuyderzee to promote the navigation of Amsterdam.

The works, begun in 1864 and executed by a company, consist, besides the digging and excavation of the canal, in the construction of a port

on the North Sea, and the embanking and draining of grounds on both sides of the canal in Ij and the Wyker Lake.

The port on the North Sea is constructed by piers, advancing into the sea, made of béton blocks, founded on large basalt enrockments, fortified on the outsides. The entrance to this port has a width of 282 yards; the depth is 26 feet under low water. The bottom of the canal west of Amsterdam is 22½ feet under canal-gauge, and will be deepened to 24¾ feet. Branch canals join it to several places, which communicated formerly with the Ij by water.

East of Amsterdam, a dike of about 1,300 yards separates the canal from the Zuyderzee. In this dike have been constructed locks of 19.65 and 10.83 yards width and 104,76.86 and 41 yards locking capacity. A large building erected on the east side of these locks contains three centrifugal pumping engines each displacing 2,166 cubic yards of water a minute, and which are to keep the water in the canal to the prescribed height.

West of Amsterdam, 1,300 yards inside the beach, the canal is separated from the North Sea by a sea-lock with an opening 19.5 yards wide, and 130 yards locking capacity, and two smaller ones 13 and 10.83 yards wide and 76 and 35.9 yards locking capacity. For these works, which are to be finished in 1877, 5,416,000 cubic yards will have to be dug out for the tract running through the sand-hills (*duinen*), and the same quantity to be dredged.

Of the 5,000 hectares of ground that are to be drained, more than half the quantity has been drained already, sold on average of 2,000 guilders per hectare, and are now under cultivation.

The expenses of constructing the canal will amount to 27,000,000 guilders. This sum is raised, partly by the sale of grounds by the subsidy of the city of Amsterdam and by the advances and guaranteeing of the interest by the Government.

During twenty years the company has the right to levy sluice, port, and canal dues according to rates to be fixed in concert with the Government.

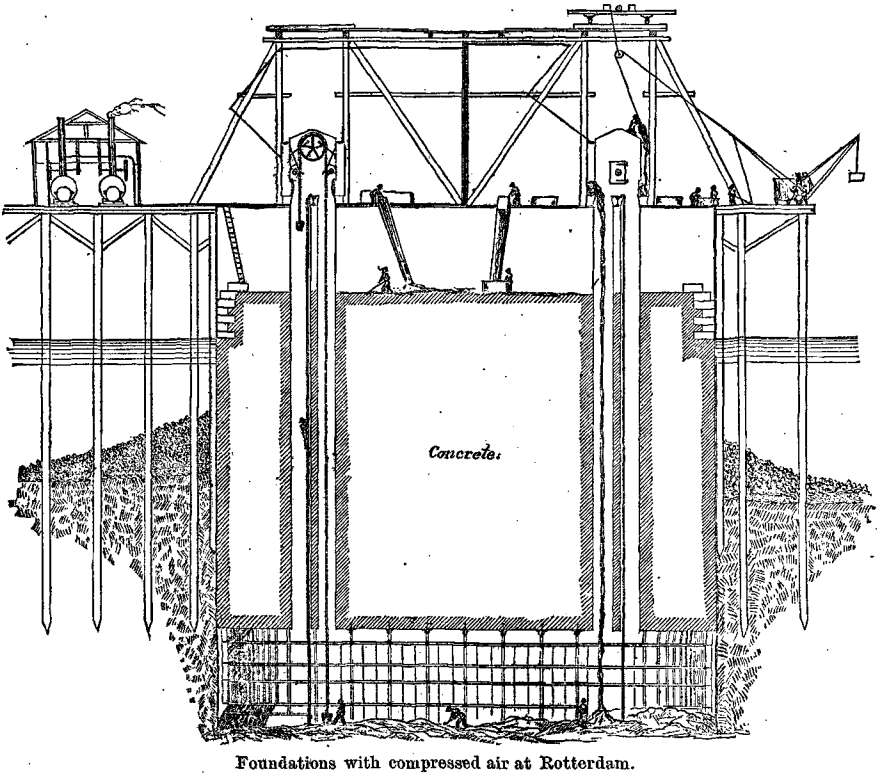
The works are executed by the company under superintendence of the Government, by the chief engineer of the hydraulic department, I. Dirks.

FOUNDATIONS WITH COMPRESSED AIR OF THE PILLARS OF THE RAILWAY BRIDGE ACROSS THE MAAS AT ROTTERDAM.

(Drawing.)

The considerable depth of the river Maas at the spot where the two piers of the bridge of the State Railway from Rotterdam to Dordrecht were to be built, viz, from 10 to 11 yards below high water, which depth increased by high floods to about 13 yards, caused these two piers to be founded by means of compressed air. This was executed in the following manner:

For every pier was used an iron cylinder, whose top was continually above water and in which at some distance above the under edge had been made a flooring. On this flooring the brick-work was continued, whilst under it the ground was excavated till the whole had sunk by its weight to such a depth that the pillar rested on a strong bottom. The space under the flooring was then filled with concrete. To be able to



Foundations with compressed air at Rotterdam.

work in this room it was necessary to remove the water by compressed air. This was performed by means of force pumps driven by two portable engines, each of 22 horse-power.

Two sets of entrance pipes had been placed on said flooring and reached above the cylinder. Every set had an air-pipe with an acclimation room, and so constructed that the concrete could be brought in and the ground excavated.

The properly called air-room, the entrance-room, and the work-room (the space under the flooring) were continually filled with compressed air. To descend into the work-room, the man had to go into the acclimation-room, shut the outer door, make the compressed air in the entrance-room escape into the acclimation-room by opening a cock; after having got the equilibrium, open the door which separates the two rooms, by which opening he could now go to the entrance-room, reshut

the door, and descend by a ladder into one of the entrance-pipes. The compressed air in the acclimation-room could be removed again from the outside by the opening of a cock, if it were necessary, before entering or leaving the acclimation-room.

The bridge, of which the superstructure is in course of construction (December, 1875), is projected by the chief engineer of the hydraulic department, N. T. Michaelis.

LOCKS AND SLUICES.

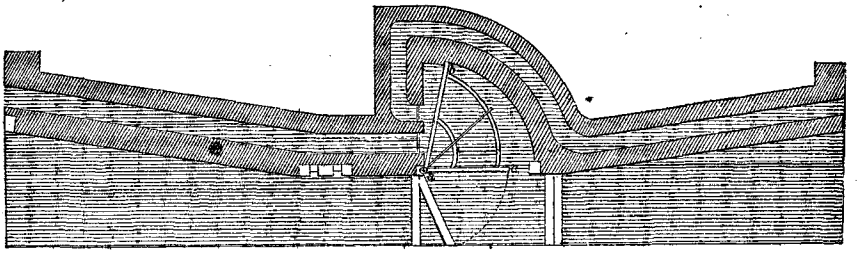
Tide-locks.—In a country intersected by so many rivers and canals, and so crowded with lakes and fens, as the kingdom of Holland (formerly the Low Countries), where a considerable foreign trade flourished even at early date, the necessity of easily transmitting ships from a higher to a lower level, and *vice versa*, must have been felt very soon.

History appears to indicate that the invention of locks is of Dutch origin, and that it dates from the Middle Ages. Locks, through which laden vessels could pass without difficulty, were known in this country as early as 1253.

It seems that the number of locks greatly increased in Holland after the year 1315. In official documents dated from 1413, mention is made of locks then being in use at Amsterdam.

The first technical description of locks is from the hand of Simon Stevin, and dates from 1618. By its being translated into foreign languages, they soon became more generally known.

Fan-locks.—Another Dutch invention relative to locks and sluices dates from the year 1808, when the inspector-general of the Government civil engineers, Mr. I. Blanken, invented the fan-locks. These pos-



Plan of Blanken's gate.—Invented in 1808.
a b, Fan. *a c*, Miter-gate.

sess the important quality of opening and shutting by the mere application of the excess of pressure of the water on either side of the gate. To effect this, each heel-post has two gates attached to it, at an angle of about 80° between them. One of them is the common miter-gate; the other has a greater width, and is called the fan. They are strongly connected together by means of coupling-beams. The horizontal section of the gate-chamber is a quadrant, one radius of which is in the

direction of the lock-wall, the arc being turned towards the same side as the miter-sill. The radius of this recess is of such a length that the fan can just turn in it, the axis of the heel-post coinciding with the center of the horizontal section.

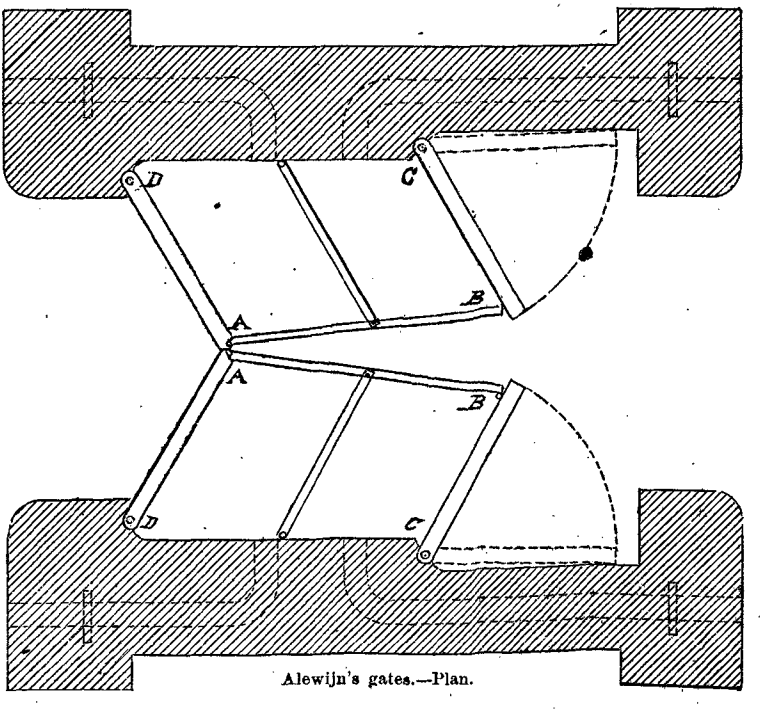
The quoins for the corner, formed by the arc and the face of the lock-wall, are cut with a square ridge, so applied that when the miter gate is shut the fan presses against it and closes the gate chamber.

By sluices with slides, there is communication between the gate-chamber and the water on either side of the gate. If then, for instance, the communication between the recess and the high water be opened, the fan will shut on account of its offering a larger surface to the pressure of the water than the miter-gate, and the two being connected, the latter is forced to shut also. This shows that these gates are able to withhold the high water on either side of the miter-gate. If, on the contrary, the gates must be opened against high water, the communication with the high water is cut off, and that with the low water opened. Then the water in the recess will fall, and for the same reason, as explained before, the fan will be pressed into the recess and the miter-gate will open against the higher water.

It is easy to conclude from this short description, of how much use this contrivance must be for outlet and inundation purposes, and that it may often be successfully applied to tide-locks and drainage sluices.

ALEWIJN'S GATES.

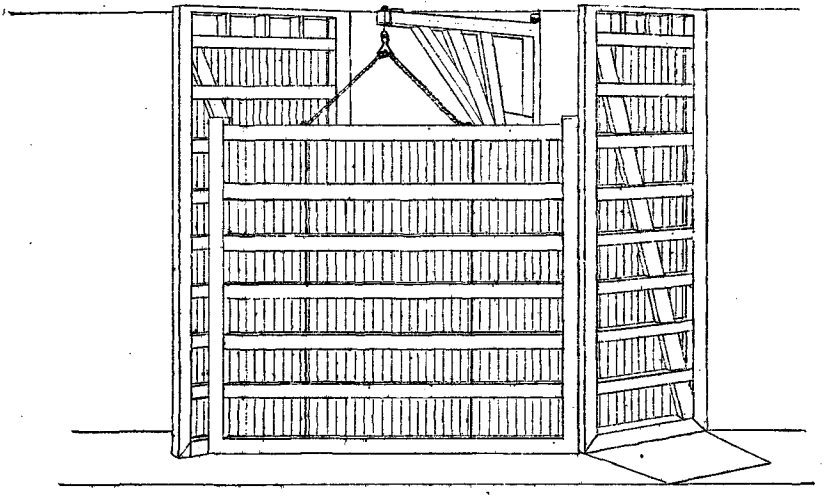
Model showing one of a pair of gates.



Alewijn's gates.—Plan.

These, like the fan-gates, are constructed to open and close automatically by taking advantage of the difference of pressure of high and low water. This result is accomplished as follows:

Each gate consists of three parts, the gate proper, D A (see figure), and the sides A B and B C, which, with the wall C D, form a water-tight chamber jointed at its four angles. This chamber can be put in communication with the high or low water by means of sluices and valves.



Alewijn's gates.—Perspective view.

When the high-water level is maintained in this chamber the gates remain closed, and can be opened by making a communication between this chamber and low water, whether the low water is at the outside or inside of the lock. There is a crane (shown in the perspective view) which helps to support the weight of the chamber. The dotted lines in the figure show the position the gates assume when open.

LOCK WILLIAM III.

(A drawing.)

The Lock William III, built in the year 1861–'64 and situated at the entrance of the North Holland Canal, opposite Amsterdam, has a length of 154 yards. It has three pair of ebb and three pair of flood-gates, partly of wood, partly of iron. They divide the lock-chamber, that is 118.3 yards long, into two smaller ones of 69.55 and 48.21 yards in length. The whole of one of the smaller chambers is used according to the size of the ship. The lock has a width of 19.71 yards, and its sill lies 7.04 yards below the water-line of the North Holland Canal.

The exhibited drawing shows how, on account of the marshy ground, engineers in Holland are often obliged to construct the foundations on piles rammed in the ground. The expenses of the lock, with its channels, amounted to 1,013,255 florins.

By employing both wooden and iron gates a comparative trial is made to judge which of them will answer best for the purpose. Up to this time, on account of the oxidation, the result is in favor of the wooden gates in locks of these dimensions.

The lock was planned and built by the chief engineer of the hydraulic department, J. F. W. Conrad.

SURFACE MODEL OF THE ZUYDERZEE, WITH MAP SHOWING THE PROJECTED DRAINING OF THE ZUYDERZEE.

Haarlem Lake is drained,
And drained is the Y;
If peace is maintained,
Zuyderzee gets dry.

This geological colored surface model represents the Zuyderzee and surrounding districts in relief. The soil of Holland is composed of peat, clay, and sand.

In the beginning of our era, the sea covered the greater part of Holland. It was only in the sixteenth century, after the invention of windmills, that a greater part of the country could be drained by wind power. In the seventeenth century the Beemster, Wormer, and other inland lakes were converted into arable land or meadows. In the present century the Haarlem Lake was drained by steam-power, and recently the sea gulf, the Y, was converted into a canal and the surrounding water into corn-fields.

It has since been proposed to drain several parts of the Zuyderzee. The largest plan, which probably will be executed ere long, is to drain the whole southern part of it (400,000 acres) by making a dike from Enkhuizen to Kampen, joining the Isle of Urk. Through and around the drained sea several canals and railways will be made, by which Amsterdam will get a good communication with the surrounding provinces.

The bottom of the sea has been explored, and consists, for a greater part, of clay a small part of peat, and the northern part of sand.

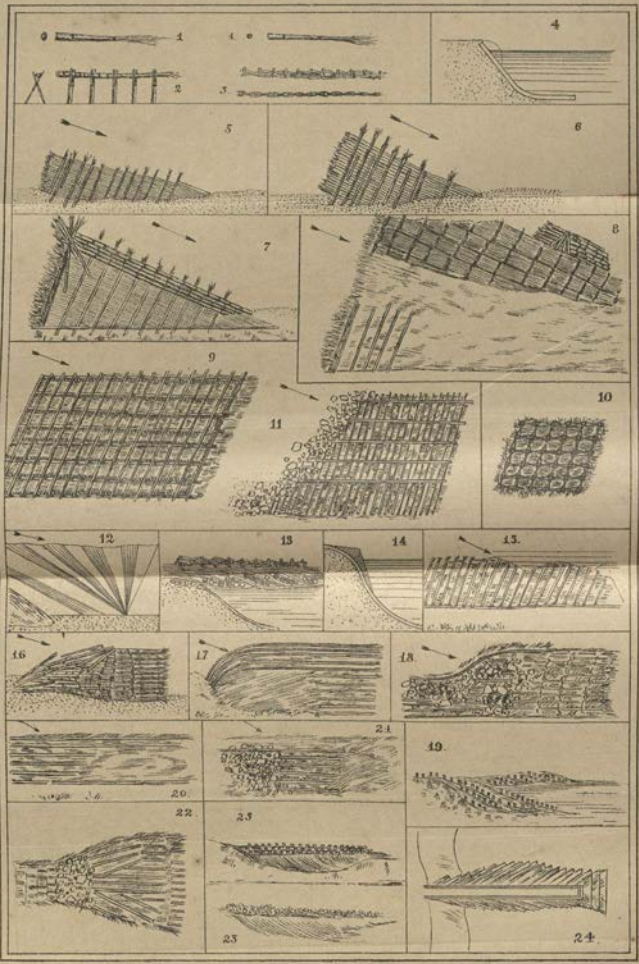
A second part proposed to be drained, includes the connection of the island Ameland with the coast of Friesland. Further, it is proposed to drain the Wieringen Lake. Concession has been asked for diking the parts of the sea near the coast of Guelderland and Overyssel. As soon as these parts are drained, there will only remain the delta included between the islands Texel and Vlieland, which will be united by a dike.

The model was made by Mr. I. P. Amersfoordt at Badhoeve, Haarlemmermeerpolder.

DRAINING OF THE HAARLEM LAKE.

(Drawing.)

This lake, which has an area of 18,154 hectares was drained in 1840 and 1852. In order to establish a regular efflux of the water of the



PROTECTION OF RIVER BANKS.

many surrounding polders, three steam-pumping stations had to be erected and the mouth at Katuyk improved. These water engines are provided with three scoop wheels of 7.15 to 5.63 yards in diameter and 2.70 to 1.95 in width, which work at seven to 10 strokes a minute, and raise the water to a height of 3 feet 3 inches.

The dike constructed round the lake has a length of about 65,000 yards. The drainage has been accomplished by means of three steam-pumping engines raising the water by means of ordinary lift-pumps. One of the water engines has eleven cast-iron pumps of 1.73 yards diameter with a piston stroke of 9.25 feet, making six strokes a minute, and raising the water 4.87 yards. At every stroke each pump discharges 6½ cubic yards of water. The two others have each eight pumps of 2 yards diameter with the same piston stroke and the same power as the former engine. The number of strokes is six to six and a half a minute, by which 7 cubic yards of water are brought up by each pump at a stroke. Nine hundred million cubic yards of water have been removed.

The expenses of this draining, borne by Government, amounted to nearly 14,000,000 of guilders, of which 9,000,000 have been reimbursed by ground sold and other profits, so that the whole work has cost nearly 4,000,000 guilders.

A SERIES OF DRAWINGS SHOWING THE DEFENSE OF RIVER BANKS AGAINST THE CURRENT.

River banks where there is no tide are protected from wear by fascine and packing works, besides dams made of fascine mattresses.

These mattresses are made of osier fagots bound together—held to the bank to be protected by ballast to prevent them from being undermined by the current. The influence of the current and ice along the upper part would soon loosen it; it is therefore strengthened by fascines forming a packing work.

EXPLANATION OF THE PLATE.

1. Fagots.
2. Construction of a weep.
3. Ground plan of a fence.
4. Filling up of the river side to be defended.
5. Beginning of the fascine work.
6. Manner of constructing the second outwork.
7. The first outwork covered with a bed of osiers.
8. The following sconces fortified by fascines.
9. Fascine work provided with fences.
10. The squares formed by the fences on a larger scale.
11. Wicker work sunk by ballast.
12. Fanlike junction of the lower mantlets, to give required length of the front line.
13. Section of fascine work.
14. Manner of fortifying the fascine work by means of packing works.
15. The sunken fascine work seen on the water level, before the waving line is filled up by wicker work.

16. Stuffing of the fascine with fagots.
17. Covering with loose osier wood.
18. Manner of sinking the fascine work.
19. Section of the fascine work.
20. Covering bed, showing fences, with fascines behind.
21. The covering bed.
22. Construction of a dam, by means of fascinage (horizontal section).
23. The same, vertical section.
24. The dam finished (horizontal projection).
25. The same, longitudinal section.

MODEL OF A "ZINKSTUK" (FASCINE BED) WITH FENCES AND OSIER WOOD IN FAGOTS.

This model shows the construction of fascine beds, which are usually made in Holland, the coffer dams and banks in the sea (such as that constructed for the new river from Rotterdam to the sea). Generally a mattress or bed consists of an under and upper grating of fagots, between which is a solid filling of osier wood or reeds, or of both together in two or three cross-layers. On the upper grating are placed cross-fences, twisted with tough willow-wood, forming cases in which is thrown the ballast to make the whole sink where it is necessary.

The following interesting description of the above is taken from a sketch of the public works in the Netherlands by L. C. Van Kerkwyk:

PROTECTION OF RIVER BANKS.

The banks of rivers beyond the reach of the tides are protected against wash and scour by different sorts of fascine work, designated in Holland by the names of "Blees," "Pak," "Baard," and "Kribwerken."

For the construction of these fascine works the following articles are employed:

1st. "Rijsbossen" (bundles of fascines), usually bound round with two tough osiers, about $4^{m}.50$ long, and measuring about $0^{m}.47$ in circumference near the lower band.

2d. "Latten" or "Gaarden" are selected tough, thin sticks.

3d. "Palen" are stakes between $1^{m}.20$ and $1^{m}.50$ long, about $0^{m}.15$ thick at the root end.

4th. "Banden" are thin top-ends of osiers of one year's growth $1^{m}.10$ or $1^{m}.20$ long.

5th. "Wiepen"; a sort of rope having the appearance of a very long and thin fagot. They are made of tough fascines, having a circumference of about $0^{m}.30$, and are bound round with seven small bands per meter. Their length depends upon the size of the mattress.

6th. "Tuinen" are wattling made of stout "latten."

7th. "Ballast," consisting of sand, broken bricks, and lumps of clay.

A. "*Bleeswerken*" (*Bleesworks*).—This is the name given to a mattress of fascines, constructed as described hereafter, which, being properly fastened on one side to the river bank, about the height of the water-level, is further loaded with ballast and made to sink against the slope of the bank, and to cover it like a sheet or curtain, so as to protect it against being undermined by the scouring current.

The width of this protection depends upon the depth of the river, and the position of the part of the bank to be protected, it being evident that, according to the spot being more or less exposed to scour, the lower edge of the fascine covering must be made to project over the bottom of the river, in order to prevent its being torn to pieces, in case the current be strong enough to deepen the river beyond the fascines.

The length of "bleesworks" is limited only by the length of the intended protection. Its thickness is usually 1m or more, but the top edge is left thinner in consequence of the mode of construction. In a strong current the up-stream edge is made a little thicker, lest the stream should bend it, roll the mattress over, and carry it off. It must be borne in mind that the validity of the work does not so much depend upon the thickness as on the proper bond between the different parts of the structure.

Before placing the protection the bank above the water must be brought into a regular shape, and a small berm made in it about 2m wide, on a level with the water. Further, it is necessary to take ample and accurate soundings, so that any irregularity in the part about to be covered may be kept in view in computing the width of the covering required at each spot.

The work should not be made unless the water be about half a meter below mean level, to insure as much as possible a continual submersion of the work after its completion, which is efficient for the preservation of the fascines.

The "bleeswork" is begun up-stream by a layer of bundles of fascines (*rijsbossen*) laid with the root ends on the bank and pointing up-stream with the top ends in a slanting direction, say at an angle of 30° to 40°; the root ends are well secured to the bank by stakes (*palen*). Upon this more layers are laid in the same direction, each springing about 0m.50 or 0m.60 forward with respect to the lower fascines, and the whole so arranged as to form a triangle, the up-stream side of which also diverges from the bank, but in an opposite direction and at an angle of about 60°. This triangle, whose up-stream side has a length of 2m to 2½m is further covered by some bundles and loose fascines laid across it, and the whole consolidated by stakes (*palen*) stuck perpendicularly through the bundles.

Across this first tier (*uitschot*), and in the direction of the up-stream edge, some fascine ropes (*wiepen*) 7m long are laid at 1m distance from one another. Along the up-stream edge two of these fascine ropes are laid close together. They are all well fastened in the bank and to the fascines, by stakes stuck through them at regular distances of about 0m.40, and are made to project 3m or 4m beyond the tier of fascines. Their ends floating on the water, also receive the necessary stakes.

In general it will be requisite, especially for the construction of this first tier, constantly to keep in view the promotion of strength and bond by an ample and judicious application of stakes and fascine ropes.

The following tiers or *uitschots* are made in about the same manner and in connection with the former. The first layer of bundles of fascines is placed again with the root ends upon the bank, in the same direction as those of the first tier, and so fastened down to the bank. The following layer is allowed to spring forward 0m.60, but the subsequent ones only about 0m.45. By allowing the second layer to spring forward a little more than the subsequent ones, the flexibility is maintained in the upper edge, which is of great use for the proper sinking of the mattress.

The tiers are made partly to cover one another, and the fascine ropes laid across the one tier are made so much longer as to be fit to receive and support the next one. The inner end is either fastened to the bank by stakes or with strong bands to the one passing over the former tier. The two fascine ropes passing over the fascines along the up-stream edge are well tied, at short intervals, to the two underneath ones.

Every tier, having the form of a trapezoid, will add about 1m.80 or 1m.50 to the width of the work in the diagonal direction in which it proceeds. They are made wider or narrower according to the strength of the current; the narrower ones of course being stronger and better connected by the fascine ropes and stakes. The lengths of these tiers increase until the full length of the up-stream edge of the mattress has been reached. Further on they vary in length according to the irregularities of bottom and the shape of the hole in the bank, the work being so constructed that the outward edge or toe forms a straight line when the mattress is sunk. So the work proceeds; the underneath fascine ropes, whilst preventing the top ends of the fascines being bent downwards by the current, establish a proper connection between the different tiers.

It is also very useful, from time to time as the work proceeds, to lay a long fascine-rope along the up-stream edge, well fastened in the bank, and to the finished work, and of course projecting beyond it in the same way as the short ones.

The full width of the intended protection along the up-stream edge being reached, the up-stream corner of the mattress will be subject to being caught and pressed down by the current on account of the downward sloping position of the bundles at the end of the tier. To prevent this some bundles are stuck in with the root ends outward, and nearly in the direction of the current and then the whole is covered with a layer of loose fascines about 0m.20 thick. This layer, in which the fascines are deposited in a direction opposite to that of the bundles underneath, is allowed to reach from 2m to 4m over the bank, where it gradually diminishes in thickness. This projecting part is necessary for a better connection of the whole with the bank. The latter layer, called the covering layer, is fastened to the fascines underneath by means of *tuinen* or wattling. This consists of lines of stakes hammered into the fascines and wattled with *latten*. The lines of wattling run in the direction of the up-stream edge, but a very strong one goes around the whole mattress, and a fascine rope is laid and well fastened along the inside of it. Parallel to this, and at the distance of 1m, another line of wattling is applied all around.

The wattlings parallel to the up-stream edge are 0m.60 or 0m.80 apart, and the ends of the wattling sticks are turned round the edge wattling and so fastened.

All the wattling are continued a little way over the bank and secured by another wattling or a fascine-rope running across them and well fastened down.

At distances of from 2m to 4m longitudinal lines of wattling are made, which are interwattled with the cross-lines of wattling, and so form a sort of box fit to receive and hold the ballast. At places where the water is rough the covering layer is fastened alternately by a line of wattling, and a fascine-rope, the latter being less subject to getting detached from the mattress by the motion of the water than the former.

The sinking of the *bleeswork* must be effected with much caution, in order to get it flat against the river bank. The influence of the current may never be lost sight of during the sinking. When from 45m to 60m run of the *bleeswork* are completed, the sinking may be started at the up-stream end. Here a vast amount of ballast is then heaped up on the point attached to the bank, so as to prevent its getting pulled out by the current during the sinking process. Then the ballasting is continued along the up-stream edge and gradually towards the middle of the river. As soon as the edge begins to sink it is necessary to load it with some gravel, as the current, then applying its full force on it, might wash away the sand and cause the mattress to rise again. At places where the mattress does not sink below the water it must be well loaded with gravel and other ballast for a better consolidation of the work with the river banks.

After being sunk the *bleeswork* must be ballasted still more, always beginning from the top and proceeding towards the lower edge. This is generally done with gravel, and continued until no more wood is felt in sounding. If the sinking is up-stream before the whole work is completed, care must be taken that 20 to 30 linear meters of the mattress are always kept afloat, otherwise the current might press it all down and prevent its completion.

Finally it must be borne in mind that this sort of protection is only applicable to the upper rivers beyond the influence of the tides, and that it cannot be made in places where there is a whirling current.

B. *"Pak or baardwerken" (packing or beardworks)*.—The *bleeswork* being applied to a spot where the river bank has been undermined and partly destroyed, it is generally requisite to restore that bank to its former direction, which, on account of its exposed position, is also effected by means of fascine-works. They are known by the name of *packing* or *beardwork*. They are so constructed as to protect the upper part of the *bleeswork* against the action of current and ice. This is done by the so-called *baardlagen* (beardlayers). Over these, and over such parts of the *bleeswork*, in the line of the

projected work, as are not entirely submerged, the bank is further raised to the required height, by means of so-called covering layers. This process is termed the *berming up* of the *bleesworks*.

The *bleesworks*, where not submerged, present a rough and wavy surface, which is filled in and leveled by packing work, so applied as to give it a smooth facing line towards the river side. The name of *beardlayer* is usually applied to all the work below the water-level.

The fascine-bank is started at the up-stream end, and this being the spot where the damage to the original river bank begins, the *bleeswork* there can never lie deep.

Consequently a layer of packing work, as just described, will usually form the first part of the work. If further on much of the river bank has been carried away, so that the packing work must pass through a certain depth of water, it progresses in the following manner:

The first bundles of fascines are laid down with the root ends resting upon the completed work and in the direction of the projected fascine-bank. The facing bundles are placed in a somewhat slanting direction, this allowing the top ends of the fascines to project into the river and to form a protection to the underlying *bleeswork*.

The second layer of bundles, deposited in the same direction as the first, is allowed to spring forward about $0^m.60$ or less, according to the depth of water. The width of each of these layers must be computed beforehand, with regard to the position it will take up after being sunk in place. Every two layers of bundles are fastened together and to the preceding work by some fascine-ropes, especially along the edges. These fascine-ropes project forward in the water.

In a strong current it may be necessary to support the top ends of the deposited bundles with some cross-bundles, but this must be avoided as much as possible in order to maintain the uniform position of the layers and the tightness of the work.

Some layers being placed, they are covered with some loose fascines, and well consolidated together and fastened to the completed work by means of fascine-ropes and wattlings. Then the mass is weighted with ballast until its surface is about level with the water. Then a second layer is constructed in the same manner, followed by a third, and so on until the required height and length has been arrived at, and the structure reposes at the bottom. Any post being properly sunk to the bottom must be well loaded with great heaps of gravel, which are not to be leveled until the work has properly settled. In a strong current gravel is also tipped along the outward slope.

The shallows of a *bleeswork* over which the fascine-bank is to pass are often but short distances, and in such cases the filling and leveling may sometimes be effected by one continuous layer, but in the actual beardworks a single layer would be too weak on account of its great length, and therefore they must be constructed as above described. In either case, however, the layers stretching forward are covered by thin layers of loose fascines in a reversed direction, beginning at the lower end.

The thickness of beard and covering layer together is usually not more than $0^m.60$. The bundles are so placed that, the top of the beardwork being reached, it is wide enough to receive the top work, whilst the top ends of the fascines of the beardwork project to about one-third of the length of the bundles beyond the base of that top work.

Any part of the beardwork having reached its proper height is further consolidated by means of longitudinal fascine-ropes, two of which run tight together along the outer edge and the others $0^m.60$ to $0^m.80$ apart. They are fastened by ten stakes per 4^m run, well hammered into the underlying fascines. For a length of 3^m to 6^m they are fastened to the completed work and from 3^m to 4^m they project forward in the water.

The top work of the actual packing work consists entirely of cross or covering layers, and has a slight slope of 1 to 20 towards the shore. The facing slope is generally 1 to 1.

The bundles are laid aslant in these cross-layers, with the top ends outward and

pointing up-stream and so far forward that one-half of the facing bundle projects beyond the section. This *beard* is of great use in protecting the work, as the ice must wear it all off before getting to the actual body of the bank. The layer is started at the outward face and carried on towards the shore, the top ends of the fascines lying uppermost. The thickness of these cross-layers must be as little as possible and may not exceed 0m.40 including the fascine-ropes. The bundles are cut loose and flattened down after being placed.

Along the outer line these layers are fastened by two lines of wattling 0m.60 apart, with a fascine-rope behind them, and further with fascine-ropes alone also 0m.60 apart; the whole is then filled in with gravel as high as the tops of the wattling and the fascine-ropes. Very often another such layer is added not more than 0m.30 thick. This is also covered with gravel, clay, or sand, so that not only the wattling but even the tops of the stakes become invisible.

The reason why the upper layers are made as thin as possible is, that the layer very soon gets loose when the wattlings are damaged by the action of the weather, the water, and the ice, and in such a case the next layer becomes the top layer, so that the work will be guarded against total destruction the more numerous the covering layers are.

C. *Kribwerken (groins)*.—The groins in the main rivers of Holland are usually made to reach 0m.20 or 0m.30 above mean summer level, rising about 1 in 200 towards the shore, or a little more in short groins, and with a top width of 3m or 4m, side slopes of 1 to 1, and an end slope of 1½ or 2 to 1.

The groins are constructed about in the same way as the *bleeswerks*, with layers springing gradually forward and covering layers alternately. If the groin is not designed at right angles with the shore, the first layer is made in the form of a triangle so as to get square work for the remainder.

During the construction care must be taken that the floating work be not made too long, as it would then be too easily turned out of its proper direction or carried away by the current.

The sinking, beginning at the root end, is effected as the work progresses. If for some reason or other it does not keep pace with the progress of the work, so that the floating work should become too extensive, an additional covering layer to about the half of the floating work may be added on the shore side and amply weighted with ballast. On the other hand, the tiers must not be made too short, for then the floating work would not be long enough with respect to the depth of water, which would give the work too much stiffness and prevent its properly sinking to the bottom.

If the body of the groin sink deeper in one place than in another, the level is made up by small covering layers. The required height of the groins is further made up of covering layers about 0m.30 thick, and after the top being leveled by filling up holes, or removing heights if necessary, a thin layer of loose fascines is spread over it. Strong lines of wattling carried longitudinally over the top, and then the whole covered with a layer of gravel, broken bricks, and clay mixed together, or with a regular basalt pitching, as the case may require.

If the bank, to which the groin is applied, be steep, or if there be any apprehension that the bottom be scoured away along the groin, it is often constructed on a foundation consisting of a "bleeswork."

In the tidal rivers the dams and groins are usually built up of a series of fascine mattresses called *zinkstukken* (sinking pieces).

Such a sinking piece consists of a lower and an upper net of fascine-ropes, between which two or three layers of bundles of fascines or reeds, or fascines and reeds (deposited in each layer at right angles with the lower one), are tightly nipped together.

The fascine-ropes, 0m.35 to 0m.40 in circumference, are made of branches of tough water-willow with their twigs left on, and of which the half is to be at least 1m and the other half at least 2m long. They are tightly bound together by 6 osier bands.

The fascine bundles are fagots of straight young willow, full of branches and

twigs 2m or 3m long, and well fastened together by at least two strong osiers. They are about 0m.45 or 0.50m in circumference at the root end, and 0m.38 or 0m.40 at the top end.

The reeds, cut with the feather on, are bound in bundles at least 2 or 2m.50 long and 0m.50 thick in circumference.

For the construction of the sinking piece a spot is commonly chosen between high and low water, as much as possible protected against the wash of the waves, and not very far from the intended site of the sinking piece. The form and size, the sort and quantity of the stone and other ballast for the sinking and subsequent loading of the mattress, all depend upon circumstances.

For the lower network fascine-ropes of the required length are laid out on the ground parallel to one another, at distances of 0m.70 to 1m from center to center. These are crossed by a similar layer, at right angles to the first, the two together forming a network of the size of the projected mattress; the ends of the fascine-ropes extending to 0m.30 beyond the last crossing. Every alternate crossing is then well tied together with tarred rope of 0m.035 circumference, 2m.50 long, or a little less if there be only two layers of fascines. The ends of these ropes are fastened to the tops of stakes stuck perpendicularly in the fascine-ropes, so that they may easily be found afterwards, when they must serve to fasten the crossings of the top network and at the same time to lash it well to the lower net. The other crossings are tied with bands of osier. The edge crossings are all fastened with rope.

Straps of strong rope 0m.07 in circumference, of sufficient length to reach far enough beyond the layers of fascines and each with a thimble in it, are fastened to the crossings of the second fascine-rope from the edge at distances of 8m. or 10m. Then the fascine filling is spread at least 0m.45 thick. The bundles are laid, as already stated, in horizontal layers, the fascines in each layer at right angles with those underneath it, and very closely packed together, so that the mattress after being securely lashed has a uniform tightness all over. The top network is then placed exactly over the lower net, with the lower fascine-ropes at right angles with the fascines of the top layer. Then the above-mentioned ropes are lashed round the corresponding crossings.

The remaining crossings are fastened by osier bands, the same as in the lower net.

Over the outer fascine-ropes all round, and also over every other adjoining, lines of wattling are placed, the stakes of which are hammered in 0m.35 to 0m.40 apart. For the wattling even and straight branches of tough water-willow are used. It is made 0m.18 high, being well hammered down, the ends of the stakes remaining 0m.05 above the wattling.

Every fourth stake is heavier than the others and called *anchor stake*. They remain with their tops 0m.10 above the wattling, and have a keyhole 0m.07 from the top, 0m.04 long and 0m.0125 wide, in which a key is hammered 0m.25 long, perpendicular to the wattling. The anchor stakes are 1m.10 and the other 1m long. These wattlings form a *gangway* along the edge of the mattress, and they divide the remaining surface in squares. In the corner-crossings of the fifth fascine-rope from the edge perpendicular to it, and further at distances of 15m, so-called *proppen* are made. They are a set of twelve to fourteen heavy stakes hammered in close together in a slanting direction, and serve as mooring posts for fastening the hawsers required for towing and for keeping the mattress in its place during the sinking. These stakes are long enough to be driven into a couple of bundles of heavy stakes fastened for their support to the lower network. A buoy properly marked, and of the necessary floating capacity, is fastened, with a strong line 3m longer than one-fourth times the depth below high water of the intended site for the sinking, to each corner, and further at every 30m distance along the longest side of the mattress. The sinking piece thus completed is towed to its place when the tide is up and placed in its proper position. For this purpose the center line of the mattress is marked by at least three perpendicular beacon poles of sufficient length, which are to be kept in the right direction

during the process of sinking. The mattress is then secured in its place by hawsers thrown around the *proppen* with wide nooses, and fastened to anchors previously deposited for the purpose. Vessels laden with clay and stone are so placed round the mattress as to insure equal division of the weight over the whole.

After being properly anchored, and each of them fastened to the opposite vessel with at least one line, the ends of ropes, called "hanging lines," reefed through the above-described straps and thimbles, are so fastened on board these boats that one end can be easily cast off. Then the ballast is discharged and divided equally over the mattress, beginning from the center, but especially in the "gangways" it must be spread with care.

In order to effect this work with requisite regularity and speed, a gang of five men per 100 square meters are wanted, besides the skippers and their men (two men on board of each barge).

So soon as the piece is sufficiently ballasted and the current diminished, the signal is given for letting go the "hanging lines" and so the mattress is allowed to sink. Immediately after the sinking the ballast boats scatter the sunken piece and discharge the remainder of the ballast as regularly as possible, one man being placed at each buoy-line to keep it clear from the stones. The buoys remain attached to the piece during twenty-four hours after the sinking; they serve to ascertain whether the mattress has sunk in the proper position. If the buoy-lines cannot be removed by pulling they are cut off as low as possible. By this process the sinking can take place so accurately that in the specifications for this sort of work no greater deviation from the projected site is allowed than one-tenth of the length or width, as the case may be, in the direction of the current, and at the utmost 1^m in the direction perpendicular to the current.

If a "sinking piece" is to be placed close to the shore, so that part of it would reach above low water, a hole must be dug or dredged to fit it in, and such part of the mattress entirely covered with a regular layer of stones. Sinking pieces adjoining other works are united with them as accurately as possible.

The above is also described in General Barnard's report on the North Sea Canal.

COAST PROTECTIONS.

DOWNS.

The Netherlands, bordered on the west by the North Sea, with the Zuyderzee in its very center, and intersected by numerous rivers, can only be protected against inundation by artificial means. It is true that, in a general sense, a natural protection is formed along the coast of the North Sea by a row of sand-hills or "downs," but these are found everywhere, and they are themselves subject to considerable damage from the wash of the waves, swept up against them in storm-tides. This causes ground-slips along the slopes, carrying away with them the "helm" or sand-oats, a species of grass planted on these slopes as a protection against the action of the wind upon the dry sand at the surface.

As a means of promoting the accumulation of sand at the foot of the downs, rows of bundles of straw are planted and the cavities made in them by the force of the wind are closed with protections of reeds.

During past centuries the barrier of sand-hills and the coast in general have been greatly encroached upon by the joint action of the

waves and the current, and especially the diminution of the coast of North Holland is fully exemplified by a comparison of the maps of the coasts of Helder and Huisduinen in 1571, of the Pettemer and Hondsbossche sea-dikes in 1730, and of Egmond aan Zee in 1686 and 1718, with those representing their condition in 1875. Since the beach has been efficiently protected against scour and the sea-dikes against the wash of the waves, their injurious effect is no longer discernible.

DIKES.

Even the downs are thus artificially protected, but the dikes are in this respect the object of the greatest care, as they require the construction of expensive works in order to put them in a position effectually to withstand the effects of the currents and storm-tides.

At places where strong currents run along the dikes, the beach must generally be artificially protected, even to a considerable extent below low water. A thick layer of heavy natural stone is the common protection below the surface of the water. Where the bottom consists of loose substance, it is made to rest upon a mattress of fascines, ingeniously woven together and inclosed between fascine-ropes (see Protection of river banks). Such a mattress is about $0^m.50$ thick, and fitted by its construction to adapt itself to the irregularities of the bottom.

Extensive submarine protections of this kind are made along the dikes in Zeeland, principally on either side of Neuzen, near Borselen, along the north side of the islands of South and North Beveland, near Stavenisse and along Schouwen Island, and also along the sea-dikes of Helder in North Holland. These works require a yearly expenditure of several hundred thousands of guilders.

Above the level of low water the protection against wash and scour consists of groins, constructed nearly at right angles to the direction of the current. They are from 100^m to 150^m long and from 100^m to 250^m apart.

The north coast of the island of Cadzand; the west and north coasts of Walcheren; the Oude Hoeve, on the Isle of Schouwen; the north coast of Goedereed; the beach near Ter Heide, Hondsbossche, Petten, and Vlieland, are regularly protected in this manner for distances of several miles, and considering that each groin (constructed of fascines and pitched with stone a width of from 8^m to 12^m) costs between 10,000 and 15,000 guilders, it will be possible to form an idea of the large amounts already laid out and still continually expended for the defense of the coast.

The body of the dikes, where not much exposed to wash, is protected by a so-called *stroobekramming*. At places where there is a broad or high beach, they are covered with fascines, with or without a pitching of stone, as the case may require. Sometimes the slopes are protected by a brick-on-edge paving.

When the dikes are exposed to the storm-tides or to heavy waves break-

ing upon them, or when the outer slope is rather steep on account of limited space, the facings of fascines and stone are strengthened by rows of piles, and sometimes the latter are mutually connected by walings.

If practicable the outer slope is divided into two parts by a berm slightly sloping towards the sea. It is made at from 1m to 4m above high-water level, from 5m to 20m wide, and covered by a revetment of sods.

Upon the sea-dikes of the province of Zeeland alone, are laid about 1,000,000 square meters of fascine protection, and 1,200,000 square meters of stone pitching, part of which must be renewed or repaired every year. This maintenance involves a yearly outlay of more than 600,000 guilders.

The principal sea-dikes of the country are the Westkapel dike in Zeeland, and the Hondsbossche, the Pettemer, and the Helder dikes in North Holland.

The Westkapel dike is 3,800m long. It is exposed to the winds ranging between southeast and north. The rise and fall of the tides is 3m.50. It has for the greater part an outward slope of 12 to 13½ to 1, and reaches from 5m to 5½m above high-water level. It is protected, from low water to between 0m.50 and 1m.50 above high water, by fascines with stone pitching, and higher up to between 2m.50 and 4m.10 above high water by *stroobekramming*. Part of it is provided with rows of piles constructed by walings.

The Hondsbossche and Pettemer sea-dikes, constructed at places where the natural barrier of downs in North Holland is interrupted, are together about 5,500m long. They face the northwest, and the fall and rise of the tides at that spot is 1m.50. The outer slope of the former, having a length of 4,500m, will be entirely covered, in the course of a year, by a pitching of basalt, which is to reach from 1m.50 below to 4m above high water. This slope is of 7 to 9 to 1, and has a berm at its foot 6m wide, pitched with stone. Between the basalt and the top, over a space 2m.50 wide, the slope is also covered with a pitching of flat unhewn stones; above this slope, which has a width of 37m, there is a turfed berm 24m wide, slightly sloping up to 5m above high water, and then an earthen dike reaching to 6m above high water.

The construction of this artificial protection, which took place in the years 1872 to 1875, has absorbed an expense of nearly 2,000,000 guilders.

The Pettemer sea-dike is protected in the same manner as the Hondsbossche, with only the following modifications: that the berm is from 1m.25 to 2m.50 above high water; that the stone pitching is carried up on the slope of the dike above the berm to 5m above high water; and that the berm itself has a stone pitching with three rows of piles between it, for breaking the waves.

The Helder sea-dike runs along the north point of the province of North Holland and the naval establishments situated there. It faces the north, and the fall and rise of the tides is about 1m.15 in that neighborhood. It is 4,575m long, and its top, which is 8m wide, reaches

from 3m.64 to 5m above high water. The outer slope is of about 5½ to 1, and is covered from the level of low water to the top by a stone pitching, at places 35m wide, and extending over an area of about 130,000 square meters. There are twelve groins of fascines projecting from the dike over the beach, and the bottom, which lies at a depth of from 22m to 37m, close to the dike, is protected against scour by a thick layer of heavy stones.

NORWAY.

GEOLOGICAL SURVEY OF SOUTHERN NORWAY.

Director, TH. KJERULF, *Christiania.*

(Maps and specimens of minerals.)

In a notice of this kind it is not possible to give even a partial account of the geology of a country, so it will be confined to a short history of the condition and extent of the survey.

The geological survey of Norway was commenced in 1858, according to a plan sketched by Th. Kjerulf (p. t. professor of mineralogy and geology at the University of Christiania) in conjunction with his collaborator, and was placed by the home department under the direction of Kjerulf and Tellef Dahl (p. t. mining master).

The work is conducted on the base of the geographical survey maps. The two or three summer months are employed in traveling, and during this time, every year since 1858, expeditions have been made, as well by the directors mentioned as by several other gentlemen engaged for traveling. Maps are published on a scale of $\frac{1}{400000}$, and there also has been commenced the publication of detail maps on a scale of $\frac{1}{100000}$, using the geographical survey rectangular maps as a base. The large manuscript map is composed of the district maps $\frac{1}{200000}$.

The institution has hitherto, from motives of economy, not had any special bureau. The numerous specimens collected have been deposited in the mineralogical cabinet at Christiania, and various synopsis and details have been published in existing journals.

The mountains of Norway consist principally of granite, gneiss, and syenite; in the eastern part are found slate and limestone.

The following minerals are worked and are important in the order named—pyrites, copper ore, iron ore, silver ore, nickel ore. Magnetic and titanic iron ores have been found; lead and zinc appear in places, also traces of gold and of coal; borings for the latter are now being made both in the north and south of Norway.

BRIDGES.

The exhibit of models and drawings of bridges is more extensive than that of any other kind of engineering; there is hardly any country that does not show its proficiency in this branch of the art, especially the United States, which, in the rooms of the American Society of Civil Engineers, exemplifies, by drawings or models, nearly every kind of bridge made.

For several reasons it was not possible nor even advisable to fully describe this branch of engineering. It would have taken time to the exclusion of more important matter. As drawings would be required, it would entail considerable expense. Bridge-building is generally confined to specialists, and it is but seldom that it is undertaken by the Government or superintended by officers of the Corps of Engineers. I have therefore confined myself to short descriptions of a few of the more notable bridges.

MODEL OF POINT BRIDGE ACROSS THE MONONGAHELA RIVER, AT PITTSBURGH, PA.

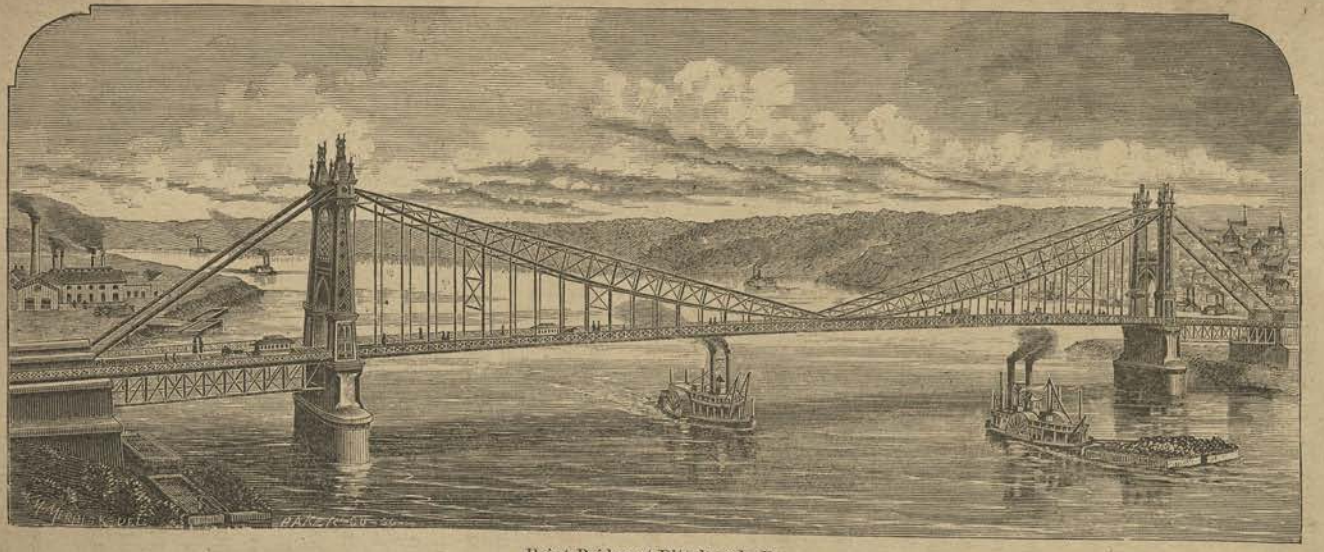
EXHIBITED BY THE AMERICAN BRIDGE COMPANY, CHICAGO.

(Scale of model, one sixty-fourth of the full size of the bridge.)

The model represents a stiffened chain suspension bridge with a center span of 800 feet, which is now in process of construction across the Monongahela River at Pittsburgh, Pa. The bridge was designed by Edward Hemberle, engineer of the American Bridge Company, which company are now building the bridge at a cost of $450,000.

The center span is 800 feet from center to center of towers, and the side spans are 145 feet each in the clear. The height of the towers above low water is 180 feet, and the deflection of the chain is 88 feet. The roadway is 20 feet wide, with double tramways and one track for a narrow-gauge railway; outside of the roadway are sidewalks 6 feet wide each. The piers and anchorages are founded upon timber platforms sunk to gravel bed. The masonry is of best quality Baden sandstone.

The superstructure will be the first example of a stiffened chain suspension bridge of long span, and will differ considerably from others in existence. The chain is designed as a catenary, and will take up all the permanent load of the structure without bringing strains on the stiffening trusses. This object will be accomplished by erecting the bridge completely before connecting the ends of the straight top chords to the center joint. The tie-rods are provided with turn-buckles, and will be so adjusted as to be strained under moving loads only. When the



Point Bridge at Pittsburgh, Pa.

Suspension Bridge [stiffened chain] crossing mouth of Monongahela River—in process of construction, 1876. Length of main span, 800 feet, height from bed of river to top of iron suspension towers, 210 feet.

bridge is half loaded the top chords of the trusses on the loaded side will be in compression, and of the unloaded side in tension. The maximum strains for the different members of the trusses occur under different positions of the moving load.

There are lateral and vibration braces between the top chords and also between the chains, proportioned to take up the strains from wind pressure upon chains and trusses. The floor is 34 feet wide between the roadway girders, which are 8 feet high, forming the handrails. The roadway girders have expansion joints every 100 feet and are suspended from the chains by flat bars 20 feet apart. At the expansion joints there are struts instead of suspenders in order to make a rigid connection between the roadway trusses and the chains. Cross-girders, 3 feet in depth, connect the stiffening girders every 20 feet, and support two lines of iron stringers. The stringers and the roadway trusses form the beams across which are placed the wooden joists for the flooring. The lateral stiffness of the floor is secured by a double system of tie-rods, and the wind pressure will be taken up by horizontal steel-wire cables placed under and connected to the floor. The towers are entirely of wrought iron, except the bases of the columns. The chains are carried over the top of the tower on wrought-iron chairs or saddles, which are movable on rollers to allow for expansion and the elongation of the back chains under strain.

The bridge is proportioned for a moving load of 1,600 pounds per lineal foot, under which, together with the weight of structure, the chains will be strained to 12,000 pounds per square inch, sectional area. The suspenders and roadway members are strained only from 8,000 pounds to 10,000 pounds per square inch. The maximum compressive strains in the towers are 9,000 pounds per square inch.

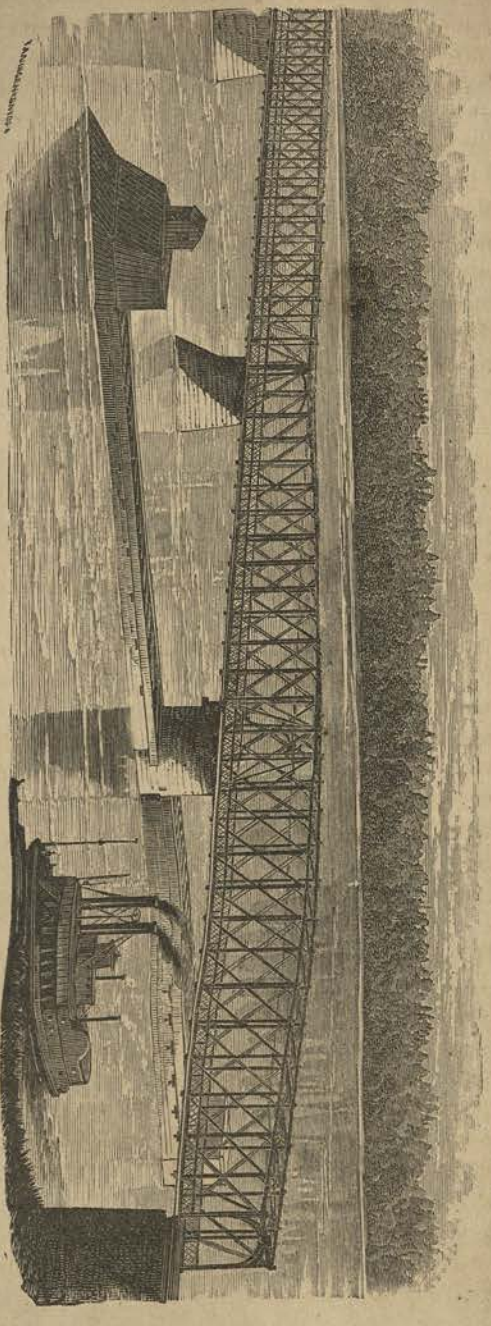
The bridge will be finished by the end of this year (1876).

KEYSTONE BRIDGE COMPANY, PITTSBURGH, PA.

This company exhibits a beautiful nickel-plated working model of the Raritan Bay Pivot Bridge, at South Amboy. This model represents a span 472 feet in length, weighing 600 tons, with engine and hydraulic machinery complete. This is the longest pivot-span in the world.

Previous to 1860 pivot-bridges were generally constructed of two disconnected spans sustained by guys depending from a central tower, or with guys to aid in stiffening wooden trusses.

In this bridge and in the Keokuk bridge these accessories were omitted, the trusses being designed to be self-supporting when revolved on the pivot center. This method of construction now prevails almost exclusively. The accompanying illustration, taken from the Keokuk bridge, shows a pivot-span 387 feet long.



Bridge over the Mississippi River at Keokuk.

AQUEDUCT OF ROQUEFAVOUR, ON THE ARC.

CANAL FROM THE DURANCE TO MARSEILLES.

(Model and drawing.)

This aqueduct was constructed for the canal from the Durance to Marseilles, and is 393^{m} in length. There are three stages of arches, of which the first comprises twelve arches of 15^{m} span; the second, fifteen arches of 16^{m}; the third, fifty-three small arches of 5^{m}.

The piers are strengthened by counterforts, the breadth of which they exceed by 1^{m}.60 in the middle and 2^{m} in the lower stage.

A small gallery with a semicircular arch of 3^{m}.30 span is formed immediately above the extrados of the first arches, and below the first platform, and gives access to the work at its level, either in the gallery or on the platform, by means of openings made in the piers, 1^{m} by 2^{m}. A similar gallery, 1^{m} by 2^{m}.50, not arched, is also established above the second row of arches and is comprised between their extrados and the level of the second platform.

For carrying the materials, uprights were fixed at the four angles of each pier, resting on two horizontal beams resting on brackets, and staged every 3^{m} in the height of the pier. These uprights support a scaffolding, to which they were joined by a system of ties, braces, and struts, and on the upper beams of this scaffolding a movable winch was placed, capable of raising blocks of 6 cubic meters, weighing as much as 15 tons. In proportion as a pier was raised 3^{m}, it was necessary to raise all the parts of the scaffolding, the supports, and the crane. By means of four jack-screws, with screws of 4^{m}.50 placed at the angles of the pier, this operation was safely accomplished in less than four hours, including the placing of the screws in position, each of them weighing more than 2 tons.

During their construction all the piers were connected by a continuous railway, supported by a series of service-bridges between them. These were easily raised according to the elevation of the masonry. Two supplementary lines were also established, one on the level of the passage formed in the piers, and the other about 2^{m} above it. They consisted of two beams thrown from one pier to the other, and strengthened by struts and uprights resting on the top of the centers. These arrangements allowed the piers and arches to be built at the same time, each division of the work having its lifting machinery, &c., independently of the other. By this method nearly 2,000 cubic meters of masonry per month were executed, and this work included the raising blocks of 8,000 kilograms to a height of 70^{m}.

The cost of the work, most of which was not performed by contract, amounted to 37,000,000 francs, about 177 francs per square meter of elevation.

This work was planned and constructed from 1841 to 1847 by M. de Montricher, engineer-in-chief "des Ponts et Chaussées."

BRIDGE, EITHER DRAW-BRIDGE OR SWING-BRIDGE AT DISCRETION, AT MARSEILLES.

This bridge has a double action, one of rotation, as in most movable bridges, the other of raising the flap (*volée*). The complete rotation of the bridge is required for vessels, but the passage of barges is effected by partially raising it, which is accomplished in less time than the rotation. By this double arrangement much time is saved in the succes. sive interruptions of the traffic on the bridge.

The length of the iron bay of the bridge is $41^{m}.09$, and its breadth is 8^{m}, comprising a line of rails, a carriage-way, and two foot-ways.

When the bridge is closed it rests on fixed blocks placed on four points of its length, also on the tops of the two quays of the passage, under the cross-beam and the second upright of the breech. In this position the friction-rollers are separated from the circular rail on which they turn by a space of 3^{m}.

The maneuvers are accomplished by means of a water-pressure of 52 atmospheres.

The water is introduced into a vertical hydraulic press, the piston of which, placed a little out of the center of gravity of the flooring in relation to the breech, assists in raising the bridge, and also serves as a pivot for its rotation.

When the piston rises, the bridge, being raised, turns round in the horizontal direction, by the aid of the breech friction-rollers, until these latter have descended sufficiently to bear upon the rail. From this moment it is the horizontal hinge of the flooring which forms the new support, and detaches itself from the nearest blocks, as it had previously detached itself from the others.

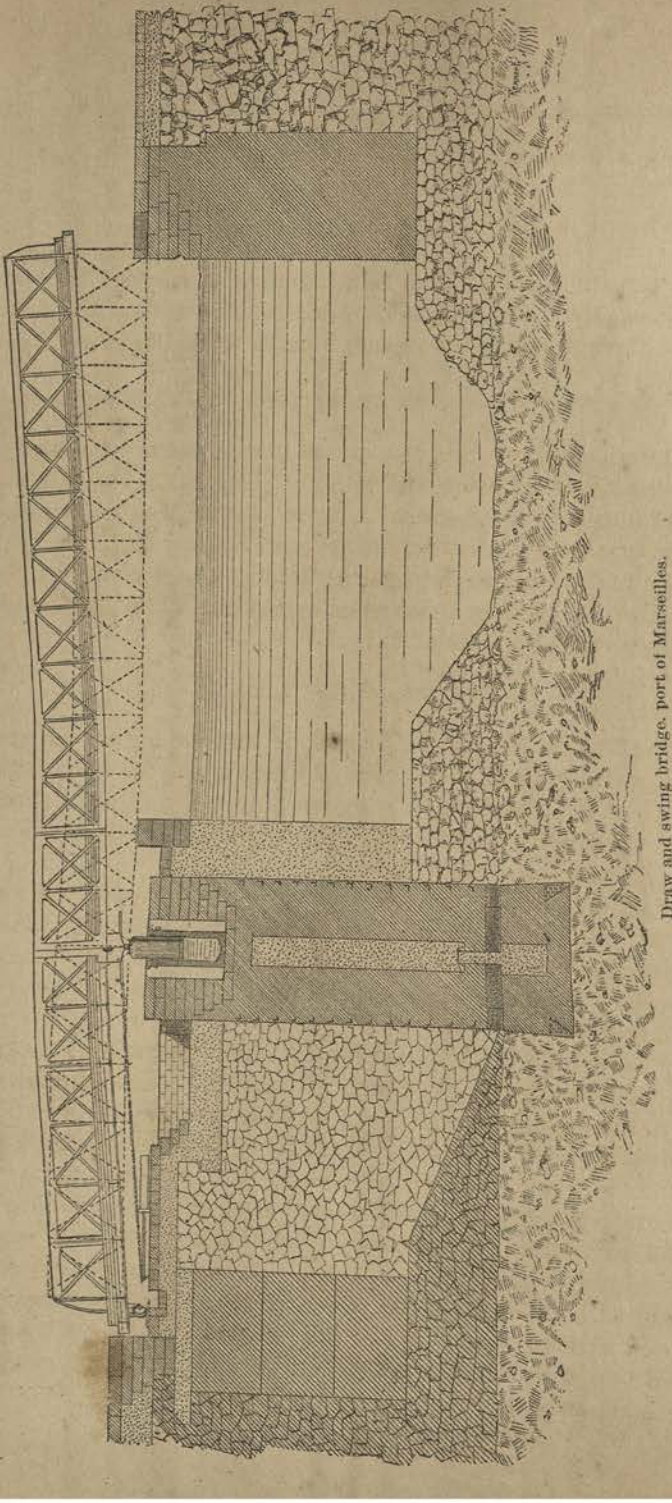
For the rotation, the rising of the pivot is arrested at 20^{cm}. For raising the bridge completely, it can be elevated to 90^{cm}. The gradient of the flooring is then 68^{mm} per meter, and the clear height between the average water-level and the bottom of the flap or fly (*volée*) is $4^{m}.60$ at its extremity, while the height of the lower end is only $1^{m}.80$.

The diameter of the piston is $0^{m}.85$, and its length 2^{m}, so that when it rises to the full extent there is still a length of $1^{m}.10$ on the press.

All the maneuvers are executed with the greatest facility, by one man at the engine, and from a place close to his lodging he can manage the working of the bridge.

The weight of this bridge is 300 tons, and it rests on a stone pier 6^{m} in diameter, founded on the rock by means of a caisson with compressed air, at a depth of 14^{m} below ebb-tides.

	Francs.
The total outlay was	316,000
For the bay, not including the masonry of the approaches	250,000
For the foundation pier	66,000
Total	316,000



Draw and swing bridge, port of Marseilles.

PORTLAND AND OTHER CEMENTS, AND THE ARTIFICIAL STONE,

EXHIBITED AT THE INTERNATIONAL EXHIBITION IN PHILADELPHIA, 1876.

Notes by Q. A. Gillmore, lieutenant-colonal, Corps of Engineers, brevet major-general, U. S. A.

CALCAREOUS CEMENTS.

This term in its most comprehensive sense embraces all the articles usually employed as the cementing material or matrix in the mason's art, and therefore includes common lime, hydraulic lime, and hydraulic cement.

COMMON LIME.

No descriptive definition of common lime is deemed necessary here, and there is nothing connected with the contributions of this material by exhibitors calling for special mention as evidences of progress in its manufacture except what may more properly be referred to in the description of the recent improvements in kilns used for burning lime, cements, and the products of the ceramic art, which will be contained in the final report to the bureau of awards.

HYDRAULIC LIME.

Hydraulic lime is obtained by burning and slaking an impure limestone containing 12 to 20 per cent of silica, or clay in which silica predominates. If silica only, or a clay containing very little alumina be present, the product is called siliceous hydraulic lime, and when otherwise, argillaceous hydraulic lime.

The slaking is usually done by the sprinkling process. A species of hydraulic lime is also produced by burning and slaking some of the varieties of argillo-magnesian limestones. They are less valuable than those derived from the siliceous and argillaceous limestones. The hydraulic lime of Teil, on exhibition, is manufactured from the quarries of siliceous limestone at Teil, canton of Viviers, department of Ardèche, France. These quarries have been worked for several centuries. They belong to the lower neocomian marls of the cretaceous formation. The stone contains from 80 to 81 per cent. of carbonate of lime, about 13 per cent. of silica, and a little less than 2 per cent. of alumina, the other ingredients being less than 2 per cent. each of the carbonates of magnesia and iron, and a little sand. The stone is burnt with coal in continuous or perpetual kilns, at a heat just sufficient to expel the carbonic acid without vitrifying any part of the stone, and when drawn is spread out in thin layers and sprinkled with water from a hose. The sprinkled lime falls into powder and is then shoveled into heaps and the slaking completed by the aid of the steam evolved. It remains in

these heaps for about ten days, and is then passed through a screen made with No. 40 brass wire, 50 to the linear inch each way. The product thus obtained is the hydraulic lime of Teil. The residue, which does not pass through the screen, consisting of particles of various sizes, from that of a small pea and under, is made up of free lime and the compounds of silica, alumina, and lime, but they do not contain sufficient free lime to cause slaking in the presence of water. This residue, when reduced to powder by grinding, constitutes the natural Portland cement exhibited by Messrs. Pavin de Lafarge and Messrs Soullier and Brunot. Both of these establishments also exhibit the Teil hydraulic lime.

The current prices delivered at Marseilles are, for the lime, 32 francs, and for the Portland cement 50 francs per ton of 2,240 pounds, in sacks, the sacks to be returned to the manufacturer. If packed in barrels the lime is 48 francs per ton and the cement 65 francs.

The works of Messrs. Pavin de Lafarge are located on the bank of the river Rhone, at the base of the opened quarries. They contain thirty-four continuous lime-kilns, each having a daily capacity of 130 cubic yards of lime. The aggregate daily consumption of coal is 100 tons. The establishment also contains thirty screens, thirty-one pairs of mill-stones, five steam-engines, one water-wheel, and is well supplied with all other appliances, such as trucks, cranes, weighing-scales, &c., for handling the lime. It gives employment to six hundred men, and manufactures its own fire-brick, above 2,000 tons annually, for lining the kilns.

The average annual production of the works is 100,000 tons (2,240 pounds) of the screened lime, and 10,000 tons of Portland cement.

In the organization and management of the business ample provision seems to have been made for promoting the health and comfort of the workmen, and for encouraging habits of industry and thrift.

For the men without families quarters are provided, where meals are served *à la carte* on checks or counters supplied by the overseer on account of each man's monthly pay, and the scale of prices is such that a prudent man can live at a cost of 25 to 30 cents per day, including a moderate allowance of common wine. This for three meals per day. The men are lodged and provided with beds for about 1 cent each per day. Of the six hundred workmen, two hundred and fifty are unmarried and are provided for in this manner.

The men with families are quartered near by in a village belonging to the company, in which there is a grocery, a bakery, and a clothing store, where all the workmen are allowed to supply themselves. Provisions are advanced on credit, without charging the consumer with interest.

A savings bank is provided, in which the workmen may deposit their money in any sum from 1 franc to 1,500 francs, upon which 4½ per cent. interest per annum is allowed. In March, 1876, the bank contained 60,000 francs belonging to employés.

A sick fund, presided over by the heads of the firm, aided by a committee of management, composed of clerks and workmen, is maintained by retaining 1½ per cent. of the earned wages, to which the establishment itself contributes a sum equal to one-fifth of the amount retained from the men. From this fund pensions are paid to the aged workmen and to the widows of workmen, and assistance is given to the sick during their absence from the works.

A hospital is provided for men without families when sick; a schoolhouse for the children, and a church and minister are also provided.

HYDRAULIC CEMENTS.

The hydraulic cements after burning do not, like the lime, slake in the presence of water, and have, therefore, to be reduced to powder by grinding. They may all be arranged in two comprehensive classes, viz:

First. The heavy, stone-setting cements, both natural and artificial, produced at a high heat. This class embraces the Portland and the Vicat cements, but as the difference between the two rests more upon a single, although distinctive, variation in the process of manufacture than upon the character of the cement produced, it is deemed proper for the purposes of this brief description to include both under the general designation of Portland cement.

Second. The light, quick-setting, natural cements, such as the Grenoble, the Rosendale, and other Roman cements.

PORTLAND CEMENT.

Portland cement is produced by burning, with a heat of great intensity and duration, sufficient to induce incipient vitrification, certain argillaceous limestones, or calcareous clays, or an artificial mixture of carbonate of lime and clay, or of lime and clay, and then reducing the burnt material to powder by grinding.

There are four methods of making this cement represented in the exhibition. They will be briefly described, although some of the manufacturers expressly declined to furnish the information asked for concerning the details of their process, while others have not responded to the inquiries addressed to them on the subject. Enough is known, however, with respect to the materials employed and the treatment to which they are subjected, in the several modes of manufacture, to enable those who have given the subject any considerable attention, to understand their essential and distinctive features.

First method.—By this method the cement is produced by burning at a high heat an argillaceous limestone containing from 77 to 80 per cent. of carbonate of lime and 20 to 23 per cent. of clay, and then grinding the burnt material to a fine powder between millstones.

The stone should be a homogeneous and intimate mixture of its constituent ingredients, and the clay in it should contain at least 1½ parts of silica to 1 of alumina. There are generally present, also, car-

bonate of magnesia and oxide of iron in small quantities, and sometimes a small percentage of the alkaline compounds, but the stones should contain not less that 94 per cent. of the essential ingredients—the carbonate of lime and clay—in order to yield a Portland cement of first quality. The presence of carbonate of magnesia becomes seriously objectionable when the amount exceeds 2½ to 3 per cent.

Only two localities are represented by this method of manufacturing Portland cement: Teil, in France, and Coplay, in the United States, near Allentown, Pa. The Teil cement is produced in the process of making the hydraulic lime of that locality, as already described.

The Coplay Cement Company exhibits three brands of cement, viz, Saylor's Portland cement, Coplay hydraulic cement, and Anchor hydraulic cement, all made from an argillaceous limestone quarried at Coplay about 6 miles from Allentown. The two last named are light, quick-setting cements.

For several years the Coplay hydraulic cement, which is good of its class, has been made from this stone by burning it in perpetual kilns, at a lower heat than necessary to produce good Portland cement.

In making the Anchor cement, a certain proportion of the raw stone is ground up with the cement to give it a darker color. This stone is not a homogeneous mixture of the constituent ingredients, and when burnt at the high or long-continued heat which Portland cement requires, it yields a heterogeneous mixture, containing Portland cement, common quick-setting cement, and common and hydraulic lime.

In the process followed in making Taylor's Portland cement, the raw stone is first finely ground between millstones, in order to obtain a homogeneous mixture of the ingredients. It is then tempered stiffly with water, and formed into lumps or balls of irregular shape, of from 3 to 5 pounds' weight, which after partial drying are burnt at a high heat in upright intermittent kilns, in layers alternating with layers of anthracite coal, about sixteen days being consumed in charging, burning, cooling, and drawing the kiln.

The establishment contains three kilns for burning the Portland cement, and four for the light cements, with ample grinding power driven by steam. The largest production in any one year has been 52,000 barrels (of 300 pounds) of the light cements. The present yearly capacity is 70,000 barrels of the light cements, and 12,000 barrels (of 400 pounds net) of Portland cement. When running full, employment is given to fifty men and boys.

At Seille, France, Portland cement is made by a mode similar to that pursued at Teil, but none of it is on exhibition, and no further reference will be made to it.

Second method.—Argillaceous chalk of the same composition as the natural stone above mentioned is used for making cement by the second method, and either the "wet process" or the "dry process" may be followed.

By the wet process the clay is mixed up with a large quantity of water, in a circular wash-mill provided with heavy iron harrows attached to the horizontal arms of a vertical revolving shaft, to secure a thorough reduction of the more solid particles to an impalpable paste. When a thorough and intimate mixture is thus effected, the semi-liquid mass is conducted away to large open reservoirs, where it is left to settle. The clear water as it rises to the surface, or as the heavier materials subside, is drained off, and the raw cement which remains is allowed to become partially dry and hard by the evaporation produced by exposure to the atmosphere.

While the mixture is in the reservoirs, samples of it are taken from time to time and made into cement in sample kilns, to verify the correctness of the proportions of carbonate of lime and clay. If any error in this particular is discovered, it is corrected by washing in new material containing an excess of the deficient ingredient, or sometimes by mixing together the contents of two or more reservoirs.

When the raw cement has attained, by drying, the consistency of very stiff clay, it is turned up to the air by shovelfuls, and after further drying, to about the condition of bricks when ready for the kiln, it is burned. Large ovens are generally used for drying the mixture in extensive works.

By the dry process the calcareous clay is ground up in a circular mill under edge runners, with just sufficient water to render it somewhat softer than masons' mortar, and is then partially dried by natural or artificial means, preferably in large shallow pans, or upon a drying floor underlaid with steam or hot-air flues. When it has become sufficiently stiff, it is molded into irregular-shaped balls by hand, or passed through a brick-making machine, and is then further dried to the condition suitable for burning. In burning, the material requires to be subjected for several hours to a heat sufficient to produce incipient vitrification, in either perpetual or intermittent kilns. Throughout Europe the prevailing custom is to burn with gas-coke, or anthracite coal, in upright, bell-shaped, intermittent kilns, the raw cement and the fuel being placed in the kiln in alternate layers and fired from below. The kiln is charged through side doors which are kept tightly closed during the process of burning. The burnt cement called "clinker" is of a dark-greenish color, and the pieces are much shrunken and contorted from the effects of the heat.

The only locality known to the writer to furnish the material for making Portland cement by the second method is near Boulogne-sur-Mer, France, where the extensive establishment of Messrs. Lonquéty & Co. is engaged in this important growing industry. The raw material employed is found in the inferior cretaceous formation and consists of an argillaceous chalk, containing from 76 to 82 per cent. of carbonate of lime and from 18 to 24 per cent. of clay. The deposit is sufficiently soft to be excavated with a pick and shovel. The chalk is first reduced to a very liquid paste by the wet process. It is then

carried to the mixing apparatus, where a small percentage of certain other ingredients, of which the exact character and amount are not known to the public, is incorporated with it. The paste is then conveyed to large reservoirs where a partial drying ensues, which is subsequently finished in drying kilns. It is then burnt in intermittent upright kilns with anthracite coal or coke, and at once ground and packed in barrels for market.

The company began manufacturing in 1856, and the amount of capital now invested in the business exceeds $500,000. The principal works are at Morais, in Boulogne, which contain 30 kilns for burning the cement, 84 drying ovens, and 24 sets of millstones; and when running to their full capacity produce 70,000 tons (of 2,204 pounds) of Portland cement annually, and give employment to 637 workmen. The company carry on less extensive works at Chatillons in Boulogne, and also at Nesles, near the city, where the quarries which supply the argillaceous chalk are located. At these 2 works 14 cement kilns and 8 drying ovens are operated, and 184 men employed. The aggregate yearly capacity of the three works is 100,000 tons of cement.

Third method.—The third method yields an artificial Portland cement by mixing together the carbonate of lime and clay. It is especially adapted to localities where chalk or soft marl abounds, although it is also applicable where the compact limestones have to be employed. Any pure or nearly pure limestone will answer, although it is well to remember that the large consumption of power involved in the reduction of the hard carbonates to powder places them under a disadvantage which practically excludes their use in regions which supply chalk or tender marl. Suitable clay is of much more rare occurrence than suitable limestone, for the reason that it must contain the silica alumina in a certain condition of commission and in certain proportions. Otherwise it will not produce good Portland cement. These conditions are sometimes imposed by mixing two or more clays together.

When the calcareous ingredient is chalk, the wet process already described is usually followed, but the chalk, especially if it contains flint, should not be allowed to mingle with the clay until it passed a fine wire sieve.

All the English Portland cements are made by the wet process with a mixture of either the white or the gray chalk, and clay procured from the shores or dredged from the bottom of the Thames or Medway. These are pulverized and mixed together in a circular wash-mill, and subsequently treated in the manner already described for the second method.

One manufactory is located at Birkenhead, and there are several on the Thames in the neighborhood of London. Those represented in the exhibition are Francis & Co., Hollick & Co., A. H. Lavers, the Wouldham Cement Company, and Eoasswood & Co., all of London.

Eoasswood & Co. exhibit specimens of cement formed into shape for testing, but no cement powder, and as the age and history of the speci-

mens are not given, it has been impossible to ascertain its strength and hardness at any given age, or to fix with any certainty its comparative value. The specimen briquettes are dense and hard, and it may perhaps be assumed that the cement of which they are made is of good standard quality.

Francis & Co. employ two hundred men, and their works have a yearly production capacity of 20,000 to 30,000 gross tons. It is expected that the capacity will be more than doubled during the present year by additional works of which the company is about to take possession.

The Parian cements manufactured and exhibited by Francis & Co. are of two grades, the superfine quality and the second quality. They are both of superior excellence and strength. The base of all Parian cements is calcined gypsum. They are suitable for interior use only, and are not hydraulic.

The Wouldham Cement Company operate sixteen kilns, and six sets of millstones, producing about 18,000 tons of Portland cement annually, and giving employment to about two hundred and fifty workmen. The specimen exhibited stands high on the list for crushing strength.

A well-known manufacturer of Portland and Parian cements, in London, in reply to inquiries addressed to him on the subject, estimates that there are from thirty to forty cement manufacturers in Great Britain, that the capital employed in the business cannot be far short of £1,500,000 sterling, and the total annual production 650,000 to 700,000 tons, giving employment to about five thousand men. This includes all descriptions of cement, the Portland, Roman, Parian, and Keene. The total quantity produced other than Portland is comparatively small.

Sweden is represented by an artificial Portland cement manufactured after this method by the Scanian Cement Company (limited) from the cretaceous chalk and clay, at Lomma, near Malmö. It is made by the wet process, and burnt with coke made on the spot from English coal. The German upright kilns are used, and they are fired intermittently. Brick-making and the quarrying of limestone for exportation are carried on by the same company. All the work of the establishment is done by the job or piece, and gives employment to from three to four hundred men. No women are employed.

The production of 1874 was valued at $138,900 gold, and comprised 16,000 barrels of Portland cement, 5,000,000 pieces of bricks, roofing and drain tiles, and 610,000 cubic feet of quarried limestone. In 1875, 38,000 pounds of Portland cement were produced.

A sick-fund and a library have been established for the benefit of the workmen.

With hard limestone the dry process is usually adopted, the raw materials, the stone and the clay, being first kiln-dried at 212° F. or above, in order to expel moisture and prevent caking in the mill, and otherwise facilitate grinding and sifting. After being dried, the two are

mixed together in suitable proportions already indicated and reduced to fine powder. One kind of machine will not suffice for grinding the raw materials economically. In some of the German manufactories three ure used, viz: (1) a stone-crushing machine, which crushes the materials in pieces not larger than a walnut; (2) a further reduction is secured by a vertical mill or edge-runner; and (3) it is then ground between horizontal millstones to a powder of which 90 per cent. should pass a wire screen of 80 fine wires to the lineal inch.

The powdered material is then tempered to a stiff paste in a brick machine and formed into bricks of a suitable size for burning, the mixture being kept warm with coils of steam pipes during this process. In some cases the liquid used for tempering is not pure water, but a mixture formed by adding to 100 parts of water from 3 to 6 parts of calcined soda, and 5 to 6 parts of newly burnt slaked chalk or lime, which is kept hot by coils of steam pipes. The burning takes place at a high heat as prescribed for the natural cement.

The Wampum Cement and Lime Company (limited) of Newcastle, Lawrence County, Pennsylvania, exhibit a Portland cement manufactured by the dry process from an artificial mixture of fossil limestone and clay. Both are ground to powder and mixed in the proper proportions with water formed into bricks, dried in ovens, and then burnt with coke at a high heat in intermittent kilns.

The works have been started within the past year and contain at present but one kiln and one run of stone. They have been planned for a capacity of 30,000 barrels per year, but cannot produce more than 10,000 barrels with the existing appliances.

William McKay, of Ottawa, Canada, exhibits a cement made in a sample kiln, with a mixture of shell-marl, clay, and carbonate of soda. The marl and clay are first dried and finely pulverized separately. Fifty parts of the clay are then mixed with 57 parts of limewater, 3 parts of the carbonate of soda, and one part of extract of wood ashes. With this clay mixture, while hot, 120 parts of the pulverized marl is thoroughly incorporated. This is then properly dried and burnt in any suitable kiln. The cement has as yet been manufactured only experimentally. The essential ingredients, the marl and the clay, are said to exist in abundance near Kingston, Canada. In tensile and compressive strength this cement compares favorably with the Portland cement of medium quality.

Fourth method.—In the fourth method the carbonate of lime is burnt and slaked before the clay is added, and the proportions are correspondingly varied by making the proper allowance for the loss of weight at this first burning. In the incorporation of the ingredients and the preparation of the mixture for the kiln, either the *dry* or the *wet* process may be followed. In the final burning, however, the heat need not be continued so long as has been found necessary in the first, second, and third methods, inasmuch as the carbonate of lime has previously been reduced to quick lime at the first burning.

The celebrated *Vicat cement*, exhibited by an importer and therefore not deemed entitled to an award, is produced by this method in France. It is considered to be superior in quality to the average Portland cements manufactured from carbonate of lime and clay, and commands a correspondingly higher price in all markets where it is known. The specimen exhibited did not fully justify this opinion of the merits of the Vicat cement.

This company have secured the use of one of the Rosendale cement manufactories and are prepared to turn all the resources of the establishment upon the production of Portland cement should the demand justify such a course. The works contain ample grinding power driven by steam, and the special mixing and drying apparatus required in this process have been introduced.

The Portland cement exhibited by Messrs. Toepffer, Grawitz & Co., of Stettin, Germany. is also made from an artificial mixture of lime and clay, and justifies by its excellence the opinion heretofore expressed that this method of obtaining cement, if properly followed, will generally produce an article superior to that made with carbonate of lime and clay.

The Stettin cement is burnt in large periodical upright kilns with coal or coke. The establishment operates fourteen of these kilns, employs six hundred men, and annually produces from 130,000 to 200,000 barrels of cement of 440 pounds gross weight.

Borst and Roggenkamp, of Delfzijl, in the Netherlands, exhibit a Portland cement of good medium quality, but no particulars with regard to the materials and process employed in its manufacture were supplied. The works were started in 1870, employ fifteen workmen, grind with a 20-horse-power engine, and produce about 5,000 gross tons annually. One-fifth of the entire production is exported.

Russia is represented by the Portland and Roman cements of C. A. Schmidt, of Riga. Both articles are creditable to the manufacturer. No detailed information concerning the process of manufacture could be procured. The yearly production of both kinds amounts to 60,000 pounds, for which about $300,000 is realized in the markets.

Some Portland cement labeled Bruno Hofmark, Port Kund, Estland, Russia, was also received and tested, and some cement tiles similarly marked were found to be very hard, strong, and well molded. No information with respect to the magnitude of the works or the raw materials used, or the process followed in the manufacture, could be procured.

The catalogued exhibit of V. B. Levin, Government of Eostland, Port Hund, near Wesenberg, could not be found, and nothing was known of it by the person in charge of the other Russian cements.

From Italy two hydraulic cements and some cement tiles are exhibited by the Società anonima per la fabbricazione del cemento, &c., Provincia di Reggio-Emilia. Both articles possess merit and are creditable to the manufacturer. The cements rank as light cements of fair quality.

From France some cement tiles and a cement catalogued as Portland cement are exhibited by the Société anonyme des chaux éminemment hydraulique de l'Homme d'Armes, près Montélimar, but no information in detail concerning the process of manufacture could be obtained.

THE LIGHT, QUICK-SETTING, NATURAL CEMENTS.

In the foregoing description some of the natural quick-setting cements have been mentioned, because it was deemed best not to separate them from the Portland cement catalogued under the same number and exhibitor.

The natural cements usually take the name of the place of manufacture. They are produced by burning at a heat sufficient to expel the carbonic acid certain argillaceous or siliceous limestones, containing less than 77 per cent. of carbonate of lime, or argillo-magnesian limestone containing less than 77 per cent. of both carbonates, and then grinding the product to a fine powder between millstones. They can be, and in France and England formerly were, produced artificially by burning a mixture of lime or carbonate of lime and clay, prior to the discovery of the process of making Portland cement by slightly varying the proportions of the ingredients and burning the mixture at a high heat. The superior qualities of the latter, producing as it does a mortar possessing about four times the strength at much less than twice the cost of the light, quick-setting, artificial cements, gradually drove them from the market, and their manufacture soon ceased and has never been resumed.

It is not expected, however, that the use of these natural cements will be superseded by that of the Portland. For certain purposes they are as necessary, not to say indispensable, at the present day as they were when their introduction revolutionized the former methods of executing submarine constructions in masonry, by taking the place of the feeble hydraulic mixtures made from hydraulic lime, trass, or natural or artificial pozzolana. They possess sufficient strength for the purpose to which they are usually applied, viz, for massive concrete foundations, for the concrete hearting and backing of thick walls faced with ashlar, and as the means of conferring the hydraulic energy upon mortar for ordinary stone and brick masonry. At the same time it must be admitted that for similar purposes good Portland cement suitably diluted with common lime in order to reduce it to the strength of the quick-setting natural cement is, in most localities, the least costly of the two.

For concrete foundations laid green in water, these quick cements are almost invariably to be preferred in the hands of ordinary workmen for the obvious reason that most of them not only hold the sand by their unctious and adhesive properties more tenaciously than the Portland cement, but their prompt induration arrests the washing effects of the water and prevents the progressive separation of the sand and cur-

rent before it has had time to proceed far enough to produce serious injury to the concrete.

Most of the cements can be suitably burnt in any kiln, and by any method that will answer for common lime, although some of them require a higher degree and a longer application of heat than will usually suffice for the pure or nearly pure carbonates.

This type of hydraulic cement makes a meager display at the exhibition, and some of the best-known and most valuable brands—foreign and domestic—are not represented at all. It is somewhat remarkable, also, that, with one or two exceptions, no statistical information was submitted, so that this report has to be prepared in great measure from data previously in the passesion of the writer.

The Cumberland Hydraulic Cement and Manufacturing Company, of Cumberland, Md., exhibit, by their agent, S. M. Hamilton, Baltimore, Md., a barrel of their cement made from an argillo-magnesian limestone, quarried near Cumberland City, on Will's Creek, not far from its confluence with the Potomac River. The stone is burnt in upright continuous kilns, in layers alternately with layers of coal. It is an excellent natural cement of the light active type, and may be made either quick or slow setting at pleasure, by mixing together in suitable proportions the products of different strata of the quarry.

The establishment contains six upright continuous kilns, and the fuel used for burning is the semi-bituminous coal of Allegany County, Maryland. Four pairs of French burr stones do the grinding. Provision is made for two additional pairs. A steam-engine furnishes ample power for the six sets of stone. A yearly productive capacity of 400,000 barrels of 300 pounds each is claimed for the works. The greatest production in any one year was 150,000 pounds. The works give employment to from twenty-five to thirty men.

Charles Tremain, of Manlius, Onondaga County, New York, exhibits a light, quick-setting cement possessing great merit, manufactured in the township of Manlius from the tentaculate or water limestone which overlies the Onondaga salt group; also some articles molded from a mixture of cement and sand, consisting of blocks of artificial stone, pieces of flagging, and ornamented architectural building blocks in different colors, with leaves, fruit, and flowers in alto-relievo. The articles are well molded, hard, and tough, giving evidence of a good quality of the cementing ingredient employed.

Some calcined gypsum for fertilizing purposes is exhibited by Mr. Tremain. This belongs to another group and is mentioned here simply because the two industries are carried on in one establishment and under one organization. The works contain thirteen kilns and four sets of 4½ feet millstones, and produced in 1874 50,000 barrels, and in 1875 48,000 barrels of cement. They give employment when running full to seventy men, while the plaster-works require from twenty to twenty-five men, according to the demand and production. The plaster interest of this establishment is one of the largest in the United States.

The Allen Cement Company of Siegfried's Bridge, Penn., exhibit a light, quick-setting cement made from anargillo-magnesian limestone of that neighborhood. The cement is of good quality and is an excellent representative of its type. It gave good results when tested, and, from the testimony of those who have used it in important constructions, no doubt can be entertained of its practical value.

The works contain two kilns and two sets of millstones and have a yearly productive capacity of 24,000 barrels. Their average yearly production since they were started, in January, 1872, has been between 15,000 and 16,000 barrels. From sixteen to eighteen men are employed constantly. The mill is arranged for two additional sets of stone.

The Howe's Cave Association, of Howe's Cave, N. Y., exhibits three brands of natural quick-setting cement, made from different strata of a ledge of argillo-magnesian limestone existing in that locality. The cement taken from one of the barrels is of good standard quality as a natural cement; that from the others is of fair medium quality, well suited for ordinary building purposes requiring the use of hydraulic cement, but unable to stand so large a dose of sand as the one first named. A stratum of stone contiguous to those which furnish the cement yields a hydraulic lime, which answers tolerably well for making Scott's selenitic mortar, although not as good as the best English hydraulic limes for that purpose. The works contain four cement kilns, and one of McCulloch's patent lime-kilns, and two runs of stone. Their yearly productive capacity is 100,000 barrels. The largest annual production has been 35,000 barrels. The business was started in 1870 and gives employment to twenty-two men.

P. Gamreau, of Quebec, exhibits a natural quick cement which is excellent of its class. Of this cement Sir William Logan in his geological report says:

> The stone contains a large proportion of clay. A specimen of the calcined and ground stone prepared for use by Mr. Gamreau, of Quebec, gave 11.60 of water and carbonic acid, and the residue consisted of lime 52.49, magnesia traces, silica 27.40, alumina and oxide of iron 12.16, sulphate of lime 7.95=100. The proportion of sulphate of lime is remarkable. It became solid in less than seventy-five minutes after mixing with water.

A more detailed analysis by F. Able, chemist of the English war department, gave results not differing materially from the foregoing. The analysis would seem to indicate that the cement would be improved in quality by burning it at a high heat, provided the stone is a homogeneous and intimate mixture of the ingredients.

The works contain two upright kilns, ellipitical in horizontal section, burnt intermittently with wood fuel, and two sets of Excelsior millstones, each capable of grinding 75 to 80 barrels of cement in 10 hours. They are driven by steam-power. The largest yearly production has been 9,000 barrels, and the average reaches 7,000 barrels. The works employ from fifteen to eighteen workmen.

Thomas Gowdie, of Limehouse, Ontario, Canada, exhibits a natural

cement, suitable for the purposes to which quick-setting cements are commonly applied, but requiring to be used with a somewhat smaller proportion of sand than some others in order to produce a mortar of superior quality. The works contain seven kilns using pine wood for burning, and one set of millstones capable of grinding 65 barrels per day. The establishment produces yearly 5,000 to 6,000 barrels of cement, 150,000 bushels of common lime, and 1,000,000 feet of lumber, besides a quantity of shingles and lath.

Before awards were recommended for any of the hydraulic cements on competitive exhibition, samples were taken and carefully tested under the direction of the writer, by Mr. James Cocroft, principal overseer of the fortifications on Staten Island, New York. Before testing, the samples were entered in a book with the names of the exhibitors, and also with numbers, and the numbers only were furnished to Mr. Cocroft with the specimens to be tried. He therefore had no knowledge of the locality or the establishment from which any particular cement was derived.

The directions were to mix the dry cement with an equal measure of clean sand, temper the mixture with water to the consistency of stiff mason's mortar, and mold it into briquettes of suitable form for giving the tensile strength. These briquettes were left in the open air one day, then immersed in water for six days, and tested when seven days old. After obtaining the tensile strength in each case, the ends of the broken specimens were ground down to one-and-a-half-inch cubes, which were used the same day for obtaining the compressive strength by crushing. The results obtained by crushing, being regarded as the truest indications of relative value, were relied upon in recommending awards.

The following table shows both the tensile and crushing strength of specimens, per square inch. It also includes some English Parian cements tested in the same manner and with the same proportions of sand as the hydraulic cements, with the exception that the specimens were not immersed in water, but were kept seven days in the open air and then crushed.

Tensile and crushing strength of Portland and other cements, exhibited at the International Exhibition in Philadelphia, 1876, as determined by Q. A. Gillmore, lieutenant-colonel, Corps of Engineers, and brevet major-general, U. S. A.

[The tensile strength was obtained on a sectional area of 2½ square inches (1½ inches by 1½ inches), and the crushing strength with 1½-inch cubes. The materials were molded in the plastic state like stiff mortar, and tested when seven days old. The hydraulic cement specimens were kept in water the last six days. The Parian cements were not put into water.]

No.	Kind of cement.	Country where made.	Proportion of dry ingredients.	Tensile strength per square inch; average of several trials.		Crushing strength per square inch; average of several trials.	
				Pounds.	Trials.	Pounds.	Trials.
	PORTLAND CEMENTS.						
1	Toepffer, Grawitz & Co., Stettin	Germany	Cement, 1; sand, 1.	216	3	1,439	12
2	Hallick & Co., London	England	do	216	3	1,330	10
3	Wouldham Cement Company, London	do	do	199	3	1,140	12
4	Saylor's Portland cement, by Coplay Cement Company, Coplay, near Allentown, Pa.	United States	do	184	2	1,078	8
5	Wampum Cement and Lime Company, Newcastle, Lawrence County, Pennsylvania.	do	do	168	3	968	12
6	Pavinde Lafarge, Teil, canton of Viviers, department of Ardèche.	France	do	147	3	931	12
7	A. H. Lavers, London	England	do	192	2	926	6
8	Francis & Co., London	do	do	163	3	907	14
9	William McKay, Ottawa	Canada	do	141	3	882	10
10	Borst & Roggenkamp, Deltezijl	Netherlands	do	132	3	826	12
11	Lonquèty & Co., Boulogne-sur-Mer	France	do	108	3	764	12
12	Riga Cement Company (by C. A. Schmidt, Riga).	Russia	do	134	2	693	5
13	Scanian Cement Company, Lomma, near Malmö.	Sweden	do	112	3	606	14
14	Bruno Hoffmark, Port Kund, Eastland	Russia	do	159	2	580	6
	ROMAN AND OTHER CEMENTS.						
15	Coplay hydraulic cement, by Coplay Cement Company, Coplay, near Allentown, Pa.	United States	do	38	2	292	8
16	Charles Tremain, Manlius, N. Y	do	do	48	3	276	12
17	Allen Cement Company, Siegfried's Bridge, Pa.	do	do	43	3	276	12
18	P. Gamreau, Quebec	Canada	do	47	2	234	8
19	Riga Cement Company (by C. A. Schmidt, Riga).	Russia	do	44	2	230	6
20	Anchor cement, by Coplay Cement Company, Coplay, near Allentown, Pa.	United States	do	41	3	208	12
21	Cumberland Hydraulic Cement Company, Cumberland, Md.	do	do	41	3	196	12
22	Société Anonyme, des chaux éminement, hydrauliques, de l'Homme d'Armes, près Montélimar.	France	do	29	2	184	7
23	Howe's Cave Association, Howe's Cave, N. Y., No. 1.	United States	do	28	2	183	6
24	Howe's Cave Association, Howe's Cave, N. Y., No. 2.	do	do	44	2	170	10
25	Howe's Cave Association, Howe's Cave, N. Y., No. 3.	do	do	31	2	170	8
26	Società Anonima, per la Fabbricazzione del cimento, provincia di Reggio, Emilia, first quality.	Italy	do	27	3	181	12
27	Società Anonima, per la Fabbricazzione del cimento, provincia di Reggio, Emilia, second quality.	do	do	22	3	154	12
28	Thomas Gowdie, of Limehouse, Ontario	Canada	do	24	2	126	8
29	A. H. Lavers, London	England	do	24	2	122	6
	PARIAN CEMENTS.						
30	Francis & Co., London, first quality	England	do	181	3	1,175	8
31	Francis & Co., London, second quality	do	do	269	3	696	12
32	A. H. Lavers, London	do	do	51	2	205	6

In explanation of the foregoing table it may be well to state that although it shows, beyond question, under the conditions named, the absolute crushing strength of the several mortars at the age of seven days, and hence, with a close approximation to accuracy the relative values for building purposes of all the specimens of cement exhibited, it may not correctly indicate the relative merits of the customary productions of the manufacturers represented. Some of them may have used especial care in preparing the articles exhibited, while others may have sent average samples from the stock on hand. The quality of the well-known English Portland cement is fairly represented in the table, while that of Lonquèty & Co. is not, for they have sent a better article to the American market by the cargo than that exhibited. The Scanian cement, from Sweden, was exposed to the air three months in a loose pile on the floor before it was tested, and it may have been injured thereby. The results obtained with it were lower than those previously reported by a Swedish engineer.

Several specimens of selenitic mortar, plastering, and concrete are exhibited by the Patent Selenitic Cement Company (limited) of London, England. They are hard, dense, and strong, but their exact composition and age are not given.

The merits of the selenitic process consist in the use of unslaked lime (which should be one of the hydraulic varieties) in such a manner, in combination with calcined gypsum, that the slaking of the lime is prevented. With suitable limes, like the Burham and the Blue Lias, and the Barron Lias limes of Great Britain, the addition of 5 to 7 per cent. of the gypsum will suffice.

The prepared selenitic lime sold in the English markets in bags is simply lime of a suitable kind, to which about 4 per cent. of calcined gypsum has been added, both having been intimately mixed and ground together and then sifted through a sieve of 30 wires to the inch both ways. At the time of using it an additional pint of the plaster to a bushel of the prepared lime is mixed in the water, making in all a little over 5 per cent. of the plaster. One bushel of prepared selenitic lime requires about six gallons of water.

The mortar may be made after the following formulæ, from prepared selenitic lime containing 4 per cent. of plaster:

IN A MORTAR MILL WITH A FIVE-FOOT PAN.

Throw into the pan of the edge-runner about 6 gallons of water, with the first gallon of which 1 pint of finely-ground plaster of Paris has been well mixed, and gradually introduce a bushel of the prepared selenitic lime; continue the grinding until the whole is reduced to a creamy paste. The sand is then to be added, and the whole to be ground together for ten minutes more.

IN A PLASTERER'S TUB.

When a mortar-mill cannot be used, an ordinary plasterer's tub, or trough, with an outlet or sluice, may be substituted. Into this tub pour

a gallon of water, to which a pint of the plaster has been added, then pour the rest of the water into the tub, and well mix; next gradually introduce a bushel of the prepared selenitic lime, which must be *thoroughly* mixed with the water in the tub. The mixture is then taken from the tub or run out by means of the sluice, and mixed with sand in the following proportions:

FOR BRICK WORK AND FIRST COAT OF PLASTER.

(No hair required.)
2 pails (6 gallons) of water.
1 pint measure of plaster.
1 bushel of prepared selenitic lime.
6 bushels of clean sharp sand.

For outside plastering use 4 bushels of sand instead of 6, and for finishing rough stucco face use 2 or 3 bushels of fine washed sand instead of 6. For first coat of lath work only use 3 bushels of clean sharp sand instead of 6, and add 1 hod of well-haired lime-putty.

For concrete 1 bushel of sharp sand to the bushel of selenitic lime instead of 6, and 6 to 8 bushels of the ballast. The addition of one-sixth bushel of best Portland cement is also recommended to improve the setting.

The prepared selenitic lime must be kept perfectly dry until made into mortar for use.

It is of the utmost importance that the mode here indicated of preparing the mortar, concrete, &c., should be observed, viz, first well stirring the plaster in the water, and then the lime into the well-mixed milk of plaster and water; otherwise the cement will slake and spoil.

Selenitic lime or mortar should not be used in conjunction with gauged stuff for cornices, screeds, &c.

The sand, ballast, or other ingredients should always be clean and free from loam. When the sand is very dry more water than the quantity above specified will be required.

No more mortar should be gauged than can be used in the same day.

If it should ever happen that mortar gets treated and sets very rapidly, add a small quantity of plaster—not exceeding half a pint of plaster—to a bushel of lime, in gauging, or make up a smaller quantity at a time.

Finely ground burnt clay (ballast) or cinders, or stone chippings, as a substitute for sand in whole or in part, can be used with great advantage in every description of work.

When the prepared selenitic lime contains the whole of the required amount of plaster, of course none is to be added at the time of using it. When no plaster has been previously mixed with the ground lime the process of preparing the mortar is the same; that is, 1 bushel of the plain lime is mixed into 6 gallons of water containing the entire dose (5 to 6 per cent.) of plaster, and the sand is then added.

The best limes for the selenitic process are the hydraulic argillaceous limes, containing from 14 to 20 per cent. of clay in which the silica predominates. From 5 to 7 per cent. of plaster will completely arrest the slaking action of such limes.

The selenitic mortars prepared and tested, of which a record is given in the same table with the cements, contained equal parts by measure of selenitic lime and sand. They were made under the personal directions of Mr. John H. Sturgis, of Boston, Mass., the agent of the London Company, with hydraulic lime manufactured specially for the purpose at Howe's Cave, N. Y., rendered selenitic with 5 per cent. of plaster of Paris.

In making the mortar, 1 measure of plaster of Paris was intimately mixed with 2 measures of water, then one more measure of water was added and mixed. Into this a mixture of the dry lime and sand, containing 20 measures of the lime and 20 of sand, was thoroughly stirred and more water added to form a stiff paste. The mortar was then molded into briquettes and tested when seven days old. They were not immersed in water at all. The crushing strength of 1½-inch cubes was 670 pounds, as an average of 20 trials, or 298 pounds per square inch. The average tensile strength from five trials was 116 pounds on a section 1½ inches by 1½ inches, or about 52 pounds per square inch.

Although the process renders this lime superior in strength to the best natural quick-setting cements, the results do not compare favorably with those obtained with the best English limes, and Mr. Sturgis states, in a written communication, that he has not yet found any lime in this country that comes quite up to his idea of what is required in this process.

CEMENTS NOT EXHIBITED.

It is to be regretted that the exhibition does not contain a more numerous display of the natural quick-setting cements, especially such as have more than local reputation.

The Rosendale cements, discovered in 1828–9 when constructing the Delaware and Hudson Canal, is derived from the tentaculate or water limestone belonging to the lower Helderberg group, known as formation II, of Prof. H. D. Rogers' classification of the rocks of Pennsylvania. The deposits are mostly found within a belt scarcely one mile wide, skirting the northern base of the Shawangunk Mountains, in the valley of Rondout Creek, Ulster County, New York.

Sixteen companies with an aggregate cash capital exceeding $1,250,000 and a yearly productive capacity of 1,500,000 barrels (of 300 pounds), are engaged in the manufacture of this cement. The greatest production of any one year was 1,400,000 barrels.

At Fayetteville, N. Y., cement has for many years been manufactured from the same ledge of stone which furnished the Manlius cement exhibited by Mr. Tremain. The yearly capacity of the Fayetteville works

is 150,000 barrels, although they have never produced over 90,000 barrels in any one year. It is also manufactured on a small scale by other parties in that neighborhood. It is also produced at Akron, Erie County, New York.

In the Western States the most extensive works are located at and near Louisville in both Kentucky and Indiana. The manufacture of cement in this locality began at Louisville in the year 1830. It is now carried on upon a large scale, by a corporation which unites several distinct and separate interests, under the name of the "Western Cement Company," of Louisville, Ky., representing a cash capital of about $600,000. The aggregate productive capacity of all the mills during a working season of 280 days is 950,000 barrels (of 300 pounds). The largest aggregate sales of any one year (1873) amounted to 450,000 barrels, and the average of the yearly sales from 1873 to 1875 (both included) was 368,419 barrels. The number of men ordinarily employed is about 170, and when running full about 400. (Condensed from information furnished by Capt. A. Mackenzie, U. S. Corps of Engineers).

At Utica, La Salle County, Illinois, natural cement is manufactured from a ledge of stone about 7 feet thick, which crops out on the margin of the Illinois River. There are two establishments engaged in the business, with an aggregate productive capacity of 300,000 barrels per year. About half that quantity per year has been made and sold.

The manufacture of cement is carried on about a mile and a half north of the city of Milwaukee, Wis., by a company recently organized. The works which have been in operation but a few months are planned for the production of 150,000 barrels in a working season of 200 days.

The James River Cement Works at Balcony Falls, Rockbridge, Va., can produce about 50,000 barrels per year.

On the Potomac River this same type of cement has for many years been made at Shepherdstown, Va., and at Round Top, three miles from Hancock, Md. The Shepherdstown Works can produce 125 barrels, and the Round Top Works nearly 350 barrels per day.

At Kingston, Barton County, Georgia, a small manufactory capable of producing 12,000 barrels per year, has quite recently been put into operation.

Near New Haven, Conn., two companies have, within the last two years, commenced making cement.

The National Portland Cement Company, of Kingston, N. Y., have recently commenced making Portland cement by the fourth method above described, the materials used being fuller's earth, kaolin, and common lime. They are thoroughly ground and mixed together in suitable proportions by the wet process, although much less water is employed than in the English works near London, or in the French works at Boulogne. The mixture when completed is in the condition ofthin, almost semi-fluid, paste. It is then run out upon a floor underlaid with warming flues, and when dried to the stiffness of potter's clay, is passed

through a brick machine. The bricks are burned in upright kilns with anthracite coal. This cement has been repeatedly tested with most excellent results. All the cements above named have been carefully examined and tested by the writer, many of them more than once, while some of them have been used for years upon Government works under his supervision. Their value for building purposes is therefore well known, but as they are not represented at the exhibition, it is deemed proper to say nothing concerning their relative merits. The brief mention of them that has been made is believed to contain statistical information of sufficient interest to justify its insertion.

No good natural hydraulic cement has yet been discovered on the Pacific coast, or if found, has not been manufactured for the market, and no Portland cement has yet been produced in that section of our country.

ARTIFICIAL STONE.

There are not many kinds of artificial stone exhibited, and none, it is believed, that are new with respect to the materials employed and the reactions brought into play to secure induration and strength. Vases, urns, fountains, statuary, tiles, building blocks, and architectural ornamentations, assume a variety of forms and degrees of excellence, but they generally have a common basis—a mixture of sand or pulverized stone and hydraulic lime or cement—and depend primarily on the quality of the materials employed, though largely on thoroughness of manipulation and skill in workmanship for such merit as they may possess.

A large proportion of the artificial stone exhibited is hard and compact. Its durability when exposed to the weather need not be questioned, especially in cases where the density and strength are satisfactory and are known to be due to the hydraulic energy of the cementing medium.

It is now a well-established fact, that a mixture of good hydraulic cement—especially of Portland or Vicat cement—and clean sand, if suitably proportioned and thoroughly mixed and compacted, will withstand without injury the disintegrating effects of alterations of heat and cold in the latitude of the Northern United States and Canada, if prepared during the spring, summer, or early autumn, so as to afford not less than six weeks or two months for the unchecked operation of "setting" before the intervention of heavy frosts. Prolonged practice also proves that a small proportion of common lime, or a large proportion of good hydraulic of either the siliceous or argillaceous type may be added to the cement, without impairing in any serious or even sensible degree the durability of the stone, or its ability to resist frost, although its strength and hardness will be diminished by such admixture. The hydraulic lime of Teil is highly prized for this purpose.

The Union Stone Company, of Boston, Mass., exhibits artificial stone made by the process of the French chemist, Sorel. The cementing substance is oxychloride of magnesium. It is produced by adding a solu-

tion of chloride of magnesium—for which bittern water, the usual refuse of seaside saltworks, is a suitable substitute—to the protoxide of magnesium obtained by calcining and grinding carbonate of magnesia (magnesite).

The articles exhibited are soapstone borders for furnace registers, stove-pipe, insulators, &c. They are made by first grinding up natural soapstone to a powder, and then thoroughly mixing it with a suitable proportion—say 8 to 10 per cent.—of the burnt and ground magnesite. This mixture is then moistened with bittern water of a density of 20° to 30° Baumé, thoroughly triturated in a suitable mill, and then compacted in strong molds of the required form by tamping it in layers. Sandstone, granite, and marble can be imitated in a similar manner.

Samples of the artificial soapstone were taken and reduced to blocks measuring $1\frac{3}{16}$ inches by $1\frac{3}{16}$ inches by $2\frac{5}{8}$ inches, which gave an average crushing strength when compressed on the side of 10,000 pounds, or 2,000 pounds per square inch. Several varieties of this artificial stone furnished by the Union Stone Company were tested by the writer, in 1870, with somewhat remarkable results. A piece of whetstone, made with flour of emery as a base, gave when two years old a crushing strength per square inch of 19,636 pounds; and some fine marble, containing 15 per cent. by weight of the calcined magnesite, gave when three years old a crushing strength of 11,555 pounds per square inch. Five other specimens of different kinds varied from 7,680 pounds to 4,923 pounds in crushing strength per square inch.

The works of the company are largely devoted to the manufacture of emery grindstones.

Mr. Dureschmidt, of Lyons, France, has on exhibition a variety of artificial emery wheels, small millstones, razor hones, whetstones, &c., and some of the artificial emery in powder. It is made by burning and grinding a mineral, called bauxite, found in the South of France. The unburnt mineral contains about 70 per cent. of alumina, 5 per cent. of peroxide of iron, 5 per cent. of silica, and 20 per cent. of water. The result of burning with the proper intensity and duration of heat, is a very hard material, fit to replace the natural emery of Turkey and Naxos for many purposes.

The process by which the powder is agglomerated and a solid body produced is not given by the exhibitor with any degree of clearness. The binding medium, however, is not hydraulic cement, nor oxychloride of magnesium, but is some material which, after being mixed with the emery, is molded into form while hot. In making some of the smaller articles, such as razor hones and knife sharpeners, the mixture is applied to wood as a sort of veneer. India rubber enters into the composition of the cement in some of the articles. The grit is of good quality and the texture firm. The information given is too meager to justify any expression of opinion concerning its durability.

The Fire-Proof Building Company, of New York, make an interest-

ing and instructive display of building materials molded into blocks in a variety of hollow and solid forms adapted to the construction of fire-proof partition walls, floors, ceilings, roofs, smoke-flues, &c. They are composed of 3 volumes of calcined gypsum, 2 of Teil hydraulic lime, and 5 of coke dust, and weigh only 60 to 61 pounds to the cubic foot. The material is a good non-conductor of heat and cold, much better than common brick indeed, resists in a high degree the action of fire and water, and although remarkably light, possesses ample strength for the purposes to which it is ordinarily applied. For floors and partitions the blocks are made hollow, with a thickness of material around the perforation varying from 1 to 2 inches, according to the size and form of the block. For floors the blocks are molded into hollow voussoirs, laid, generally, on the longer flanges of iron beams, so as to produce a horizontal surface on the top and on the bottom, flush with the upper and the lower edges of the beam, respectively, the hollow forming a series of tubes parallel to the beams. For roofs the blocks may be thin, like tiles or flagging, and broad enough to reach from rafter to rafter. If the latter be of flanged iron, the flanges may support the flags. Slating can be applied in the ordinary way, as the material is soft enough to receive nails.

The exhibitors illustrate the method of using their material by a full-sized model of a portion of a house showing the top-floor, partition and exterior walls, and a mansard roof. The steep part of the roof is faced inside and out with thin blocks set between iron rafters and resting on the flanges. The hollow partition blocks are usually made about 2 feet long and 1½ feet high, and are perforated vertically. They are laid up in horizontal courses, breaking the vertical joints in such manner that the apertures extend continuously from bottom to top of the partition. It cannot be doubted that safety from conflagrations would be greatly increased if the method of building here indicated were frequently followed.

The large sewer pipes, sewer culverts, and flagging stones exhibited by E. P. Albert, of New York, were made from a mixture of sand, kaolin, rosin, and lime. The articles are hard, possess a close texture and sufficient strength, and are impervious to water. The durability of the material for sewers has not yet been demonstrated. A piece of it was exposed to the weather five years in New York, without deterioration.

The sand (150 pounds) and the clay (30 pounds) are first carefully dried by artificial heat and then thoroughly mixed together in an iron kettle. The melted rosin (25 pounds) is then mixed in and the whole stirred to an adhesive paste, after which 1 pound of causting lime is added and stirred in. The material is poured into molds while hot and compacted by pressure. The advantage claimed for it is its relative cheapness when molded in large sizes.

The Phœnix Stone Manufacturing Company, at Philadelphia, is represented by a very creditable collection of artificial building blocks and

flagging stones, in some of which the sand is replaced by furnace flag, and in others by marble dust. The cementing medium is a mixture of natural hydraulic cement and common lime. A circumstance deserving especial mention in connection with the productions of this company is that the materials, after being mixed together with very little water, are compacted in the mold by the repeated blow of a steam hammer weighing about 2,500 pounds. They are so thoroughly consolidated by this method that the blocks can be handled at once, and the flagging stones ranged upon edge.

The net cost of manufacturing and placing on cars flags 15 inches square and 2¼ inches thick, composed of one measure of cement, 2 of slaked lime, and 5 to 6 of pulverized furnace slag, is 5 to 6 cents per superficial foot. The use of marble dust instead of sand increases the cost of production about 2 cents per square foot.

The power, a sixty horse-power engine, which works the hammer, also runs a stone crusher for pulverizing marble and other stones to be used instead of sand or furnace slag.

In the manufacture of artificial stone, the length of time that must usually be allowed for the molded block to attain a certain degree of hardness and strength before it can be transported and used has always caused no little expense and inconvenience. The most obvious remedy for this was to increase the proportion of the cementing substance, although it also increased the cost of production. The latest device is to cause the freshly-molded material to be surrounded and as far as possible permeated with carbonic acid gas, by which a portion of the lime present in the free state or otherwise is converted into a carbonate, and an additional indurating agent thus introduced. The gas is generated in an ordinary charcoal furnace and conducted through a pipe into a close chamber containing the freshly-molded stone to be treated. In its passage it unites with steam from a boiler on top of the furnace, and the vapor of water and the gas penetrate the chamber and remain mingled together in it. The action upon the specimen is more rapid when the temperature is above 100° Fahr. The articles should remain in the chamber four or five days.

Roland & Sprogle, of New York City, and George Richardson, of Milwaukee, Wis., exhibit apparatus for this process. Both embody the same principle, and there is no essential difference in the two methods of applying it.

Roland & Sprogle also have on exhibition a fine collection of paving tiles, building blocks, miniature burial cases, match boxes, and other articles, made with a mixture of hydraulic cement, common lime, and sand, all hardened by the carbureting process. The selling price of the 2¼-inch flagging is 25 cents per square foot, that of plain building blocks 60 to 70 cents per cubic foot, and that of ornamented blocks 90 cents to $1.25 per cubic foot. The building stones generally contain 1 volume of Portland cement, one volume of Rosendale cement, one-half

volume of slaked lime powder, and four volumes of clean fine sand. The specimens exhibited are well molded, of uniform color, free from efflorescence, and hard and strong. The molding is done by hand-tamping.

Mr. Richardson, who calls the process *carbonizing* and the product *carbonized* stone, exhibits a block of the material and some sewer pipe, composed of hydraulic cement one volume, and sand two volumes, a portion of the cement being Portland. He uses no common lime. He also exhibits an iron mold for making 6-inch sewer pipe, the sections of the pipe being connected by a collar joint. Each section is molded with a longitudinal rib along the bottom, called the bed piece, which has the same projection as the collar beyond the exterior circumference of the pipe, and supports the section in its place when laid, and enables the thickness of the pipe to be somewhat reduced without diminishing its transverse strength.

The value of this carbureting or carbonizing process does not appear to be restricted to simply hastening the induration, but it introduces an additional source of hardness, the subcarbonate of lime, which would not otherwise appear for many years, or at best but feebly, except on those surfaces exposed to direct contact with the air, and for a limited depth only. It is believed, therefore, that the ultimate strength and hardness of the stone are somewhat, though not materially, increased by this process. Whether the extra expense which it involves will prevent its general adoption is a question yet to be demonstrated.

James F. Allen, of Philadelphia, exhibits artificial imitations of polished marbles and other stones, in columns, pedestals, pilasters, wainscoting, mantels, and slabs. The imitations are excellent, the Egyptian green, the verd-antique, the Tennessee marble, the black marble of Lake Champlain, lapis lazuli, Lisbon, Sienna, Brocatello, Scotch granite, blood-stone, &c., being beautifully reproduced in their polished appearance. The body of all these imitations is either calcined gypsum or Keene's cement applied to a skeleton or core of wood. The columns and pedestals are therefore hollow, the core being formed of slats with openings between them like lathing. The coloring materials are pigments of various kinds, indigo, gamboge, chrome-yellow, Indian red, &c., mixed up with the plaster and water to the condition of a stiff paste, and then applied to the plaster or cement a day or two after the core has received its first rough coat. The Keene's cement is used for the finishing layer on flat but not on round surfaces, as it is much harder to work than the plaster compositions. The columns are turned and polished in a lathe. In the Levant and verd-antique marbles fragments of natural alabaster are embedded in the body while soft. The polishing is done with water and pumice and other stones of different grades of fineness.

The selling price of these articles appears to be comparatively high. Columns 9 feet high, exclusive of base and capital, and 13 inches in diameter, sell for $80, singly, and something less in sets; pedestals 1 foot in diameter and 3½ feet high, including the base, $35, and a good pattern

of wainscoting about 4 feet high $6.50 per lineal foot. Plain slabs are sold for 80 cents and upwards per square foot.

P. P. Quackenbos, of Philadelphia, exhibits four large ornamented vases of artificial stone, composed of hydraulic cement and sand, and perhaps a little common lime. The articles are well molded and the material is hard and strong. It is not known whether the process followed in manipulating and compacting the materials was in any respects peculiar.

Wilson Mitchell, of Philadelphia, has on exhibition some portsilica paving tiles, some plain gray, and others colored red, yellow, and blue, well adapted for paving foot paths, areas, cellars, churches, &c.

Wilmer & Herd, of Strathroy, Canada, display a vase about 3 feet high and a window cap made with a mixture of hydraulic lime and cement.

W. W. Trip, of Providence, exhibits a garden seat, a large vase with cover, a carriage step, and garden curb or bordering, made with cement and sand, possessing a good degree of strength and hardness.

Geronino Boada, of Matero, near Barcelona, Spain, has on exhibition some balusters, slabs, and small ornamented building blocks, composed of hydraulic cement and sand, hard, strong, and fairly molded. A church front in Barcelona is built of the same material.

From Santiago, Chili, José Gabriel Cadiz exhibits marble mantels, fluted pilasters of variegated marble, and a number of tiles, all very hard, dense, and strong. The body is concrete faced with a fine-grained composition. No information of the process of manufacture could be obtained.

From the same city, R. Escudero, exhibits artificial grindstones, balusters, and railing, composed apparently of siliceous and hydraulic cement of good quality, well molded, and hard and strong.

Several of the parties having hydraulic cement on exhibition also make a more or less prominent, and some of them a very creditable, display of artificial stone or béton, into which their cement enters as the binding medium, in order to show its strength and general fitness for a special branch of industry. Notably among these, in addition to those named, are L. and E. Parinde Lafarge, of Teil, France; the Coplay Cement Company, of Allentown, Pa.; the Wampum Cement and Lime Company, of Newcastle, Pa., and Lonquéty & Co., of Boulogne, France.

IMPROVEMENT OF THE MISSISSIPPI.

MODEL OF MATTRESS USED IN CONSTRUCTION OF THE SOUTH PASS JETTIES, MISSISSIPPI RIVER.

(Scale, $\frac{1}{10}$.)

Exhibited by James B. Eads.

The model consists of two gridiron frames of timber, each 12 by 6 feet. The timbers themselves are 1 by 1¼ inches. The frames are 6 inches apart and filled in between with branches of willow packed rather loosely. The whole is held together with wrought-iron bolts 6 inches apart around the periphery and with wooden pegs 6 inches apart over the body of the mattress. This model is exhibited in the room of the American Society of Civil Engineers. There is no written discription accompanying it.

For the account here given of the improvement of the Mississippi River I am indebted to Col. James H. Simpson, Corps of Engineers, brevet brigadier general, U. S. A., in charge of the improvement:

The first steps taken for the improvement of any part of the section of the Mississippi lying between the Illinois and Ohio Rivers of which any record is available were taken in 1836, when an appropriation of $15,000 was made by Congress for the improvement of the harbor of Saint Louis. This was followed by a further appropriation of $35,000 in 1837. The record of work done under these appropriations is contained in the reports of Lieut. Robert E. Lee, dated December 6, 1837, and October 24, 1838. At that time the object was to bring the channel back to the Saint Louis front which it had deserted. The river was then divided by Bloody Island, and the eastern chute was the principal channel.

The work done by the United States was limited to a longitudinal pier in extension of the lower point of the island, and a deflecting dike, starting from the Illinois side, near the foot of what was then known as Kerr's Island, and extending towards the head of Bloody Island. These worke were repaired, extended, and supplemented by the city of Saint Louis from time to time. Of the work by the city no satisfactory record seems to have been kept.

Surveys of the shore lines in the vicinity of Saint Louis were made in 1803, 1808, 1815, 1817, 1818, 1835, 1837, 1839, 1843, 1849, 1852, 1861, and 1862, of which a compilation was made, by order of Rear-Admiral C. H. Davis, U. S. N., by F. H. Gerdes, Assistant United States Coast Survey, which has not been published. Of these surveys those previous to 1837 were probably made under the Land Department; that of 1837 by Lieutenant Lee; the remainder probably by the Engineer Department of the city of Saint Louis. A survey was made in 1843 by Capt. T. J. Cram, Corps of Topographical Engineers, U. S. A., of which a report was made, dated February 3, 1844.

The scheme of improvement presented by Captain Cram was not undertaken by the United States, and no further steps were taken by the General Government for the improvement of the river, other than by removing snags and other obstructions from the navigable channel, until 1870. During this interval, in addition to the surveys above mentioned, a careful survey was made under the city of Saint Louis, by William E. Merrill, major of Engineers, U. S. A., of which a valuable report was made to the mayor and city engineer, dated May 1, 1869, and published with the mayor's message and other documents in 1869. In 1870, a survey was begun, under an order from Congress, of the river between Alton and the mouth of the Meramec, including the harbors at Alton

and Saint Louis, and report made by Capt. C. J. Allen, Corps of Engineers, U. S. A., to Lieut. Col. W. F. Raynolds, Corps of Engineers. The reports of Colonel Raynolds and Captain Allen constitute Appendix I 2, Report of Chief of Engineers, U. S. A., 1871, pages 312-327.

Surveys were continued during 1871 and additional reports were made by the same officers, which constitute Appendix I 8 and 9, Report of Chief of Engineers, U. S. A., 1872, pages 348-358.

Following these reports a Board of Engineers was convened by Special Orders No. 20, dated February 7, 1872. The report of the Board was dated April 13, 1872, and constitutes Appendix I 10, Report of Chief of Engineers, U. S. A., 1872, pages 358-367. Upon the recommedation of this Board an appropriation of $25,000 was made, by act approved June 10, 1872, for the improvement of the Mississippi between the Illinois and Missouri, and $100,000 for the improvement between the Missouri and Meramec. Also an order was made for the extension of the surveys to the mouth of the Ohio.

Under the above-mentioned appropriations works were undertaken including a dam at Alton, revetments at Sawyer Bend, and the raising and extension of a dike in Saint Louis Harbor. These being representative of the three classes of works required for the general improvement of the river, their construction involved the study of all the conditions of such structures, and the works themselves became the types which have been developed and modified in subsequent works.

Under the order for survey from the Missouri to the Ohio, a survey and partial estimate for the improvement of the whole section was submitted, under date December 18, 1872, and printed as part of Senate Document No. 25, Forty-second Congress, third session, page 64.

Up to this point the project of improvement was indefinite, and all that had been done was without a fixed understanding of the nature and scope of the undertaking. The report last mentioned was followed by an appropriation of $200,000 for the improvement of the Mississippi between the Illinois and Ohio; but its expenditure was restricted to the section between the Missouri and Meramec.

The importance of the subject of the improvement of transportation facilities about this time led to the appointment by the Senate of the United States of a Select Committee on Transportation Routes to the Seaboard, which committee made a comprehensive report, printed as Senate Document, Report No. 307, parts 1 and 2, in 1874. According to the recommendation of the committee, surveys and estimates were ordered for the improvement of the Mississippi, together with other routes, and a definite standard to which the improvement should attain was for the first time given. Under this order the maps and plans which constitute the contribution of this improvement to the Centennial Exhibition were prepared. The report accompanying the maps constitute Appendix C C 4, Report of Chief of Engineers, U. S. A., 1875, pages 471-495, part 2.

Appropriations were made annually to the amount of $200,000 for the years 1874 and 1875, and in 1876 of $229,600 for work in this section; the reports showing progress of work are published in the reports of the Chief of Engineers for 1873, pages 442-459; for 1874, part 1, pages 323-338; for 1875, part 1, pages 476-512.

PHYSICAL DESCRIPTION.

The Mississippi River, between the Illinois and Ohio, is divided by natural characteristics into three sections.

The *first*, extending from the Illinois to the Missouri, a distance of 24½ miles, is distinguished from the other sections by comparatively clear water, discolored by earthy and vegetable matter, but not sufficiently charged to afford a sediment when the river is below the mean stage, so long as the water is in motion; becoming tur-

bid as the river rises, sand, clays, and fine gravel are borne along in considerable quantities; the alluvial banks are eroded, and this portion of the river becomes assimilated to the section below the Missouri, when that section is below the mean and approaching the low stage. The average slope of this section at low water is 0.440 foot per mile, and the current strong. The slope and current depend very much on the relative stages of the Upper Mississippi and the Missouri Rivers, increasing or diminishing as the relative volume of the Mississippi increases or diminishes. From the mouth of the Illinois to Alton, a distance of 16½ miles, the eastern shore of the river is a rock bluff rising to a height of from 75 to 150 feet, except where broken by ravines and the narrow valleys of unimportant creeks. On the west the bank is continuously alluvial, and the bottom lands are common to the Mississippi and Missouri Rivers, here separated by a neck of land from 2 to 4 miles in width.

The *second* section extends from the mouth of the Missouri to Commerce, a distance of 162 miles. This section derives its distinguishing features from the Missouri; turbid waters, shifting bars and channels, rapid erosions of alluvial banks, and extensive accretions, building up and removing islands, tow-heads, and battures, with great rapidity. Seen at the higher stages, the crumbling banks, falling in masses, the spoil of the forests covering the surface, and the boiling, swirling current show the power to be encountered; and seen at low water, the wide wastes of sand-bars, bristling with snags, and drift of every size and shape, with here and there the dismembered skeletons of man's work, memorials of disaster, as forcibly suggest that to undertake the control of the forces here developed is no light task.

From the mouth of the Missouri to Saint Louis, a distance of 15 miles, the river does not touch the bluff on either side. A prolongation of the rock formation of the west side is exposed at the chain of rocks, where a ledge extends about one-third of the distance across the river bed. The rock probably underlies the alluvium on the Missouri side at no great depth, for a considerable distance below the chain. With these exceptions—and the latter is not positively proven—there is nothing to check erosion on either side of the river from the mouth of the Missouri to Saint Louis.

Below Saint Louis the river follows the Missouri bluff closely for 55 miles, the only exception being at Rush Tower Bend, where a former island has become connected with the Missouri shore. Above Saint Genevieve the river leaves the bluff, returning to it near Saint Mary's. Below Saint Mary's it trends to the eastward, meeting the Illinois bluff at the mouth of the Kaskaskia, and follows this bluff to Liberty, whence it again is turned toward Missouri, reaching the bluffs at Big Eddy, and follows close at their foot to Cape Cinq' Hommes.

Here the valley is at its narrowest and rocks appear on both sides. The Illinois bluff recedes from the river near Liverpool, and the river continues along the Missouri bluff. A few miles below, the isolated bluffs near Grand Tower are found on the Illinois side. Low grounds to the eastward of these isolated islands of rock indicate that the river once flowed to the eastward of them, and that the opening through which the river now flows is the result of some unknown operation of nature.

Below Grand Tower the river follows the Missouri bluffs closely for a long distance, receding from them near Bainbridge, touching again at Cape Girardeau. Here the main Missouri bluff recedes from the river and appears no more. A short distance below Cape Girardeau a depression allows the Mississippi waters in floods to escape into the swamps, and thence into the Saint Francis. Bluffs again appear on both sides of the river at Cape La Croix, continuing for several miles, and terminating at Commerce, but the bluff on the west is isolated, and apparently has been detached from the Illinois highlands. Near Commerce the bluffs recede and the valley expands into the great alluvial basin of the Lower Mississippi.

Throughout the second section the river is, as a rule, held in on one side by rocky bluffs, and is remarkably direct in its general course; only when it leaves the bluffs, as noted, does it work out the long, sweeping curves to be expected in great rivers.

Below the junction of the Missouri and Mississippi the waters of the two rivers

flow for many miles side by side with a distinct line of division. As far down as Carondelet, muddy water from the Missouri may be dipped on one side of a boat and the comparatively clear water of the Upper Mississippi from the other. Long after the line of division is lost to the eye, the difference in the water obtained from different sides of the stream is strongly marked.

The river receives in this section two tributaries of considerable size, the Meramec from Missouri and the Kaskaskia from Illinois. But their contributions to the volume are too small at low stages to have much practical influence upon the navigation and but little upon the improvement of that navigation. The contributions of sediment, though considerable at times, are usually so small, compared with the immense quantities brought in by the Missouri, and excavated by the river itself from its banks and bed, that its effect is not discoverable.

The valley throughout this section, except near Grand Tower and at the Grand Chain, is from 3 to 8 miles in width, and at the excepted localities a true river valley of the usual width exists at Grand Tower to the eastward of all the bluffs found on the Illinois side, and at Grand Chain to the westward of those found on the Missouri side. Nearly the whole of this area is subject to overflow in time of floods. The ground generally slopes back from the river to the sloughs and lagoons with which the bottom is interspersed; and, as in the like manner the ground slopes from the farther bank of the slough, or lagoon, the probability that these lagoons have at some time been channels carrying large volumes of water is established. Many think it proves them to be sites of old beds of the river, a conclusion which is possible but not necessary, since any considerable volume of water escaping over the banks of a minor channel would produce the terraced formation which characterizes these river bottoms.

The *third* section, extending from Commerce to the mouth of the Ohio, a distance of 37½ miles, derives its distinguishing characteristics from the entrance into the alluvial region, where the uniform texture of the soil allows the river to shape its course without restriction; and secondly, from the influence of the Ohio.

The times of flood of the Ohio and Mississippi are very different; and as the Ohio alone is able to cause a rise to a stage 40 feet above low water, when the Mississippi is comparatively low, the phenomena of backwater are of frequent occurrence, and its ordinary influence extends as far as Commerce, frequently farther. When the Ohio is high and the Mississippi low, the current through this section is slack, but when the conditions are reversed the current becomes very rapid. Owing, in a great measure, to these excessive changes of velocity, the channel is very unstable and the erosions extensive, as also the accretions.

The foregoing are the principal distinctive features of the sections as they present themselves to the eye.

It must not be understood that the description above refers to the navigable channel, when the river is spoken of as following the bluffs, or in stating that the course of the river is remarkably direct. The bed of the river is so broad that the channel meanders from side to side within the bed just as the bed itself meanders in the valley from bluff to bluff, and as by erosions and deposits the bed of the river, in long periods of time, traverses the valley, so the channel traverses the bed from bank to bank, justifying the remark often heard, that "not a square rod of the bed could be pointed out that had not, at some time, been covered by the track of steamboats."

The movement of the bed is ordinarily so slow that the impression to a casual observer would be that, as a general rule, the changes of the river were comparatively slight and of no great importance, as they do not, within short periods, so completely alter the contour of the bends and reaches as to attract notice. Local observers, on the other hand, noting the disappearance of landmarks, realize that the changes are great, and, keeping no exact record, naturally take an exaggerated idea of the extent and rapidity of the changes.

The shifting of the navigable channel is continual, sometimes in progressive movement; often in sudden leaps; the water forsaking one course and cutting out a new channel, in a very different direction, with very little warning.

SURVEYS.

The unstable character of the bars and channels renders it impracticable to execute surveys and maps giving in detail the hydrography of the river or the exact form of the bars. If, by elaborate survey, these features were determined, by the time the maps could be executed the changes would be so great as to render them useless for any practical purposes. For this reason, maps, descriptions, and plans, relating to the Mississippi must of necessity be confined to general features; details would tend to confuse and deceive rather than assist in comprehending the real character of the river, and the mode of dealing with it practically.

The map from Alton to the mouth of the Meramec is constructed from surveys made in 1870, 1871, and 1872, and does not show the present river as faithfully as could be desired. Very important changes have taken place at and below the mouth of the Missouri since these surveys were made. Below the Meramec, the shore-lines, at all points where improvements are desirable, were determined by actual survey during the season of 1874. At such parts of the river as are now unobstructed by bars, the shores are taken from the best data of former surveys, corrected by reference to the points established by the triangulation made in 1873 and 1874. Although not strictly accurate in matters of detail, the fixed triangulation points forbid errors of sufficient importance to vitiate any conclusions that will be drawn from these maps. The small scale of the map submitted, and the fleeting character of hydrographic features in a silt-bearing river, prevent any attempt to show soundings. A dotted line shows in important localities the channel as it existed at the time the surveys were made, and does not profess to show the channel during the season, nor as it existed at any specified date for the whole length of river shown. A considerable portion of the survey was made when the water was at the mean stage, another part at a stage approaching low water, but none at extreme low water; consequently, it must be borne in mind that the channel marked out is more direct than a low-water channel.

Detail-maps of the several localities have been prepared for special studies of localities.

The surveys already executed afford much valuable information as to what the tendencies of the river are, but do not give any information as to what has been or what will be. It is essential that a continuous series of surveys should be made henceforth, as long as the improvement of the river is incomplete; and it is to be regretted that no surveys were made previous to 1873 which can be made available in the study of the physics and hydraulics of this portion of the Mississippi.

DISCHARGE AT LOW WATER.

Discharge-measurements were made during 1873 and 1874, whenever the surveying party should find a suitable place and opportunity to take the necessary observations without too great sacrifice of other duties. The series is short, and observations were never taken twice in the same locality; consequently the results must not be considered final nor the conclusions indicated as anything more than approximations.

Table of approximate discharges, &c.

Number.	Localities.	Elevation of water above low water.	Date of observation.	Sectional area.	Width.	Mean depth.	Mean mid depth, velocity per second.	Discharge.	Remarks.
		Feet.		*Sq. Feet.*	*Feet.*	*Feet.*	*Feet.*	*Cu. feet.*	
1	Below foot of Carroll's Island.	21.8	May 17, 1873.	73.664	2,500	29.4	5.005	368,747	
2	Brickey's Mill....	19.6	July 23 and 24, 1873.	54,152	1,850	20.9	5.209	282,108	
3	One mile above mouth of Ohio River.	14.54	July 13, 1874.	39,508	2,425	16.3	5.13	202,524	River rising 0.2 foot in 24 hours.
4	Philadelphia Point.	11.75	June 5 and 6, 1874.	42,187	3,740	11.2	3.51	148,103	River falling 0.5 foot in 24 hours.
5	Three-fourths of a mile above Chester.	10.25	Aug. 23, 1873.	26,912	1,740	15.5	3.69	99,312	River falling 0.18 foot in 24 hours.
6	Near foot of Arsenal Island.	6.0	Dec. 4 and 5, 1874.	26,281	2,500	10.5	2.80	72,487	River falling 0.25 foot in 24 hours.
7	Cape Girardeau ..	6.9	Oct. 23 and 24, 1873.	20,756	1,730	12.0	3.44	71,413	River falling 0.2 foot in 24 hours.

None of these measurements affording an extreme low-water discharge between the mouths of the Ohio and Missouri Rivers, we are compelled to deduce it approximately from the observations made at comparatively low stages. Referring to the table and comparing the two observations numbered 6 and 7, when the stages of water were, respectively, 6 feet and 6.9 feet above low water, it will be observed that the amount of the first was 72,487 cubic feet, and that of the latter 71,413 cubic feet the former exceeding the latter by 1,074 cubic feet, although taken apparently at a lower stage of water.

Accepting these results as approximately correct, they suggest the fact that the bottom rises and falls to a certain extent as well as the water surface; hence, it is not possible, having a true cross-section at one stage of water, and knowing the velocities at much lower stages, to obtain a discharge for those stages by making the proper reduction in depth and corresponding reduction of sectional area; for the area may be lessened by deposits or increased by the scour during the interval.

Now, if a section of river could be found having an unchanging bottom, by the proper reduction of cross-section to the low-water stage, we might be able to obtain an approximate discharge for extreme low water. This condition is approximately fulfilled at the Chester section, where the bed of the channel proper is solid rock, The proper reduction being made, the sectional area becomes 14,986 square feet.

The velocity at this section for a low-water discharge is arrived at in the following manner. Comparison of the stages of water when the Cape Girardeau and Chester discharges were taken shows that there is an apparent difference of elevation of 3.35 feet. The Chester section reduced to this stage gives a sectional area of 21,805 square feet. Comparing this area with that obtained at Cape Girardeau, by observation it was found to be 1,049 square feet in excess. Now, since this area obtained by reduction is greater at Chester than that obtained by observation at Cape Girardeau, the velocity must be less at Chester than at Cape Girardeau. Dividing the discharge by the sectional area obtained by reduction, we obtain a mean velocity at this stage (6.9 above low water) of 3.28 feet per second. Assuming that this velocity continues to diminish in the same ratio,

$$\frac{(V - V^1)(d' - d'')}{d - d'} = V' - V''$$

to a low-water stage, we obtain 2.44 feet per second as the mean velocity for a low-water discharge at the Chester section.

We now have the probable low-water area, 14,986 square feet; and the probable

low-water velocity, 2.44 feet per second; their product, 36,565 cubic feet, is the probable low-water discharge. We can now assume any mean depth of water as a minimum; 10 feet would probably be most desirable. By using this depth (or any other desired) and the low-water discharge as constants, we can ascertain the proper width of water-way at different localities where different velocities exist.

The following table is presented as an application of this:

Discharge ÷ velocity per second = sectional area ÷ mean depth = width water-way.				
	Feet.		*Feet.*	*Feet.*
36,565	2	18,282	10	1,828
36,565	3	12,188	10	1,218
36,565	4	9,141	10	914

The fallacy in the reasoning by which the above conclusion is reached lies chiefly in the assumption that a stage of 6.9 feet above low water at one point corresponds to the same stage at a point 70 miles distant. The exact low-water reference being unknown as yet at the localities where these discharges were taken, the conclusions reached are far from satisfactory, but are the best approximations now available.

No observations having been made during an extreme high-water stage, no data exists for determining the proper width between outer levees; therefore no attempt can be made to determine this until more extensive observations have been made bearing on the subject.

From such observations as are on record, it is believed that at a bank-full stage, about 25 feet above low water, 3,500 feet is the proper approximate width.

SAND-BARS AND THEIR MOVEMENTS.

The unstable character of the Mississippi has its origin in the rapidity of the currents, the excessive variations of volume, and in the loose texture of the soil through which the river works its way. Since none of these causes of instability can be changed or modified essentially, it is necessary to accept this character as an absolute condition, and study its phenomena, in order to gain acquaintance with the laws or generalized facts, and thus be able to obtain the assistance of nature's forces, rather than contend against them. Soundings, taken at various times and localities, prove conclusively that the depth of water in the river does not follow the rise and fall of the surface as given by gauge-readings. While one would not be justified in asserting it as a fact universally, it is abundantly proven that the bars, at least, rise and fall with the water to a degree that may be expressed in the statement that a wave of sand accompanies the wave of water in a rise, but moving at a slower rate. If a cross-section of the river be taken during high water, the soundings, reduced by the known height of the surface above low water, will become zero, or even a minus quantity in many sections, and always much smaller than the depth known to exist at the same locality at low stages.

Again, comparing the depth at various low stages upon the same bar, it will be found that the depth upon the bar does not increase or diminish in the same ratio as the water rises or falls, but, contrary to what would be expected, the depth often increases as the river falls, and diminishes as the water rises on the gauge. In the language of boatmen, the bars "cut out" in a falling and "flatten out" in a rising river.

Since we know that, at ordinary high waters, the low-water channels are completely filled with sand, or very nearly so, the question is suggested whether in great floods the same is not true in a greater degree; in other words, whether a considerable part of the ordinary river-bed is not occupied by sand instead of water. If this be so—and facts, so far as observed, indicate that it is—the height reached by floods depends upon the amount of sand accumulated in the bed as much as upon the volume of water

passing; and, moreover, it becomes probable that the influence of tributaries in raising the river often exceeds the ratio of the volume of water they contribute, as they come in at times very highly charged with sediment, especially the Missouri. A portion of this sediment is deposited, occupying and obstructing the water-way; the remainder, borne along mingled with the waters, and thus diminishing their fluidity, and therefore the velocity of the flow, also assists in the heaping up of the waters.

At first thought the discussion of flood phenomena may not seem pertinent to the subject of improving the channel. Since navigation is not impeded at floods, many hold to the opinion that, so far as navigation is concerned, the river at its higher stages may be left to itself, and that practical operations for improvement should be limited to the low-water bed, and look only to deepening the water over the bars. But if the sand-wave fills the ordinary bed at times of flood to any great extent, there is reason to apprehend that an entirely new channel may be made, flanking the works of improvement, and disturbing the channel above and below for considerable distances. Moreover, there must always be a period, during the decline from a flood-stage, when the channel maintained by the flood must change, to adapt itself to the diminished volume, for the floods, following the straightest cuts and along the shortest lines, convey the heavier and harder materials with them. The low-water volume, small in quantity and possessing less power, generally works its way through the softer portions of the bed along the bends, &c.

The shifting of the channel, due to the varying volume of water, is a fact observable in all rivers, and the Mississippi differs only in that the changes are more radical. During this transition period the channel must be uncertain and comparatively shoal, and the only remedy is to control the flow at all stages, at least to the extent of keeping the permanent low-water channel within the width of the channel at ordinary high water. As the high-water channel is always much wider than the low, this would seem to be practicable, the main difficulty arising from the fact that the low-water channel is much more tortuous than the high.

Considered as to hydrography and the direction of the currents, the Mississippi, when low, is not the same river as when high, and obviously the problem of a permanent and complete improvement involves the reconciliation of these diversities.

The bars in the Mississippi are chiefly composed of movable sand, and travel downstream at a rate in proportion to the velocity of the current, changing their shape as they pass the bends of the river or meet with obstructions that lessen the velocity or deflect the current from its natural direction. These bars overlap each other so that a longitudinal section of the river-bed would show inequalities similar to the surface of a shingle roof, as shown by the full lines in Fig. 1. The dotted line shows the changes that are constantly taking place in the surface of the bars. The material from *a a a* is deposited in the dead angle *b b b*, the bars preserving substantially their shape, but traveling downstream. A plan of sand bars upon a perfectly straight reach of river, which prevents a cross-section approximating the trapezoidal form, the crest of the bar being the highest about midway between banks is shown in Fig. 2. Of course we do not find this regularity in all parts of the river. In fact, if it were possible to make the river perfectly straight, it would not long remain so, unless the banks were protected from erosion.

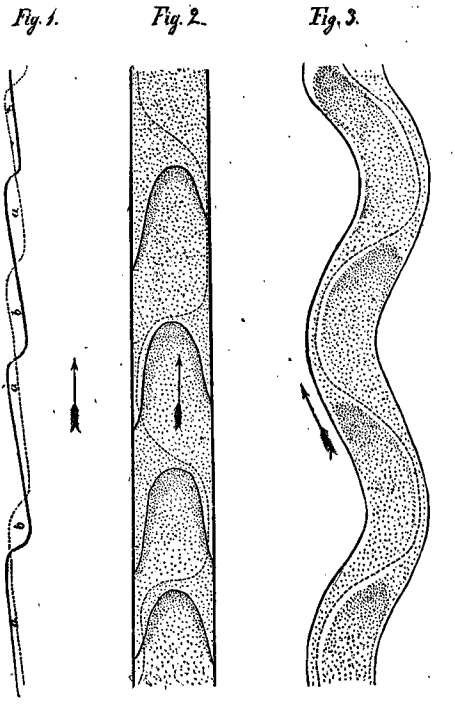
We usually find reaches, which are straight in general direction, broken up into very short curves and approaching the form presented at well-defined curves, as shown in Fig. 3. The introduction of any foreign substance, such as snags, drift-piles &c., will change materially the shape and movement of the bars; so also will the curves of the banks.

When the river rises the movement of the bars is more rapid, and as the bottom of the river also rises and falls again with the water, the former channel being obliterated, a new channel is formed as the water recedes, the crest of the bar giving way at its lowest point, which is usually near the shore, generally leaving a pool of water.

The foregoing is given as a generalized statement of the form of the bars, and sug-

gests that the position of the bars is determined by the outline of the banks. The frequent apparent exceptions found in the Mississippi are reconcilable by keeping in mind a distinction between the banks of the low-water river and those of the river at high stages. The dry bars form secondary banks at low stages, and to these banks the extreme low-water channels conform.

It is a fact well known that in the case of rivers flowing through alluvion the channel follows a succession of curves, convex connecting with concave, and that the deepest water generally follows the concave bank. The steamboat crossings are along diagonal lines, running from near the lowest point of one concavity to a point above the apex of its alternate opposite concavity.



Even in rivers flowing through alluvial beds, the apparent anomaly of the channel being found directly under the point occasionally obtains, and can be explained by the fact that the velocity carries the gravel and other hard materials past the point, the inertia of the moving mass being so great as to keep it in its direct path until arrested by the opposite shore.

The channel through the section between Commerce and the mouth of the Ohio is subject to greater variations than the other sections, because the soil is more uniformly alluvial, and the variations of velocity very great. As already stated, the current is slack when the Ohio is relatively higher than the Mississippi; at such times much of the sediment brought to this section must necessarily be deposited by the comparatively still water, to be removed in whole or in part when, the conditions being reversed, the current through this section becomes more rapid than at any other part of the river. The changes consequent upon these variations of velocity differ in degree only from those occurring in other sections, and will require greater care and expense in any works for its improvement than elsewhere, but there is no reason to doubt that success can be assured in the application of the same general system.

The banks of alluvion in all the sections are light and movable, with strata of quicksand underlying or outcropping in many places. These banks are constantly changing from the action of the currents upon them. In addition, the water when high saturates the bank, while at the same time it aids in supporting it. As the water falls, the saturated earth, under its increased weight and its tenacity lessened by saturation, falls off in large masses and is taken up by the current. The quicksand, semi-fluid as it is when it moves laterally, removes the support of the superincumbent mass—another cause of slides.

Another potent cause of action upon the banks comes from the waves of passing steamers, and their action has been found energetic enough to affect the bank, even when revetted with stone, the wave-action being propagated through the interstices of the revetment stone.

At what depth the bed-rock underlies the sand, gravel, &c., of the river is only known for a few places where borings have been made. But the question cannot have much practical bearing, since the depth to the rock is usually so great as to forbid the idea of seeking rock foundations.

THEORIES OF TRANSPORTATION OF SEDIMENT.

The transportation of sediment by running water is a topic that has been often discussed, and many theories advanced to explain the facts. The discrepancies of the theories even now held by different writers is proof that the facts have not been collected and studied to a degree justifying any statement being put forward as absolute truth.

It is recognized that the power to abrade and transport is related to the velocity; also to the character of material. Besides these obvious elements there are others—continuity and change of direction and depth—which have an undoubted influence; but the relative power of each element in producing the result is wholly undetermined; nor is it certainly known whether all the elements have been discovered.

A shade of the truth probably pervades all the theories, but mixed with much error, arising from their having been based upon the study of a single stream, and that presenting probably extreme conditions. From France comes the theory of the controlling influence of breaks in the continuity of the direction or in the changes of direction; from India, the theory that water, flowing between banks or over beds of loose material carries a load of sediment, bearing a fixed ratio to the velocity, subject to modifications by depth, and, of course, the character of the material carried. Briefly stated, in a river flowing in a bed whose material is uniform, the amount of sediment borne varies directly as the velocity and inversely as the depth; and that the water passing any section is always charged with the full amount of matter which it is capable of carrying. Consequently, the load borne varies with every change of velocity, however slight; dropping a portion of the load when velocity is diminished from any cause producing sand-bars, and recovering its load by attack on the bottom or banks when the velocity increases, resulting in erosions; while with a uniform velocity neither erosion nor deposit can take place. According to this theory, uniform motion, with its attendant saturation with sediment, should be the object.

According to the impact and friction or change of direction theory, deposits are inevitable if sediment is borne, and erosions must occur if the angle of impact exceeds a limit proportioned to the resisting power of the soil; consequently, according to this theory, the object is to diminish the amount of material in motion by protecting the banks exposed to attack, and to prevent the occasion for injurious action by securing an unbroken continuity to direction, and reduction of the angle of impact by regulating the outline of banks to a succession of osculating curves.

Experience has shown that practice under the latter theory is attended with success. The former theory rests upon observations, but has not been tested by practical works for the improvement of rivers based upon the principles given. One prominent fact observable on the Mississippi is contradictory of the practical part of the equi-

librium or India theory, for, as has already been stated, the waters of the Mississippi and Missouri Rivers flow side by side for many miles, with a distinct line of division between clear and muddy waters. Where the waters of these rivers first come in contact, the clear water of the Mississippi is pressed against the alluvial bank on the Illinois side, which it cuts into rapidly, and in the clear part of the river is found the deepest water and most rapid current. Passing into Sawyer Bend, on the Missouri side, the Missouri water comes in contact with a bank similar to that previously pressed by the Mississippi waters, and although thick with sediment, the erosion at this place fully equals that above; continuing past the city of Saint Louis, the water comes to the bridge with the line of division yet distinct, and immediately below the clear Mississippi water presses upon a bar upon the Illinois side without any remarkable attack. Thus it may be traced until the difference in the waters fades out, but without developing anywhere the marked erosion of the Illinois bank or the alternative extensive deposits on the Missouri side which the theory would demand; for, according to it, it should be impossible for two neighboring fillets of water to flow over the same bed, and with equal velocities, without carrying an equal load. The case has been traced so far that each kind of water has undergone both increase and diminution of velocity, and many changes of depth and direction.

Many facts are required to establish a theory; one, if unreconciled, can disprove it. When the attention of the author of this theory was called to the fact here presented, he replied:

"* * * In the examples of the large American rivers you refer to, where the Missouri brings down water quite turbid, while the Mississippi is nearly a clear stream, I would observe that, where the load of solid matter held in suspension is not probably the one-thousandth part of the weight of the water flowing down, it may be practically impossible to observe any retarding of the velocity on account of the load transported; but with such torrents as above described,* bringing down a large per centage of solid matter, and with water loaded with sewage, I believe it is possible by experiment to discover a difference in the velocities, as compared with pure water with the same slope and transverse section.

"The examples above given of water flowing at great velocities pitching about bowlders show that a certain power must be exerted which offers some resistance to the flow of the water, and if so with rocks or bowlders forced to bound forward, so with shingle, sand, or the finest particles of clay will the flow of every stream be somewhat retarded in some proportion, due to the quantity and quality of the load transported. In the case of the Missouri River, I believe that it will be found that the rock and soil of which its catchment basin consists is composed of materials that have already undergone the abrasion of water, while that of the Mississippi will be more crystalline, and sand will predominate instead of mud. In proof of the power of flowing water picking up its load, I may here state that in the cold season the water is quite clear, and a rupee can be seen at depths exceeding 10 feet at the head of the Ganges Canal; at the sixth mile the rupee is lost sight of at 5 feet below the surface; at the twelfth mile, about 4 feet; at 3 feet depth the rupee can be seen some 20 miles down the canal; and so on did the muddiness of the water go on increasing till about the fortieth mile, when a saturated load of solid matter was attained. It was therefore in these first 40 miles that all serious action on the canal bed and banks took place prior to the time I held up the surface of the water at the falls; and in my report of November, 1861, I estimated the cutting that had then taken place in the first 40 miles at some eighty or ninety millions of cubic feet of earth. It was by observing this cutting in the upper portions of the canal, and the tendency of the stream to change its channel lower down, which led me to think of this abrading and transporting power of water; and it was my native foreman, Sahib Sing, who first drew my attention to the fact that this abrading action on the bed only took place when the water admitted into the canal was comparatively clear, and not when

* Certain mountain-torrents in India, here referred to.

the Ganges was in flood, passing down turbid water, which can only be compared to pea-soup, for nearly six months in the year."

The writer of the above, in dwelling upon the turbidness of the water in question, seems to have lost sight of the fact, or at least does not seem to attach much importance to it, that large quantities of matter may be held in solution, the capacity for which varies with different soils; also, of the fact that the capacity of a stream to abrade is mainly due to its living force ($M V^2$), a function of its mass and velocity; and that the factors may change and the product remain the same. The resistance to abrasion depends upon the nature and shape of the banks and bottom. The matter becomes complicated when taken up in this shape; and while Mr. Login's statement of facts is entitled to full respect and belief for the locality to which he refers, it does not follow, by any means, that the theory is applicable to the Mississippi River.

In the first part of the foregoing extract Mr. Login is defending the proposition that the transportation of sediment, being work, must be at the expense of force, and, in the case of running water, gravity being the moving force, its expenditure must diminish the velocity. Whether this be accepted, or the view taken that mixture of foreign matter diminishes the fluidity of the water, is practically immaterial; the velocity would be less in either case than for pure water, though, as he says, the effect would be inappreciable except in extreme cases. The proportion of sediment in this part of the Mississippi River under discussion has been stated, in a report made to the public-school board of Saint Louis, to be $\frac{1}{3226}$ part in volume. Noting that Mr. Login likens the sediment-saturated waters he observed to pea-soup, and remembering that his idea of pea-soup is English, it is evident that the waters of the Mississippi do not approach such saturation; consequently, the theory does not apply practically to the Mississippi.

Mr. Login's observations show that the point of saturation is sometimes reached; and he does not assert that water flowing over an unstable soil is always so saturated: rather the contrary, for he says that it required the active erosion for a distance of 40 miles in the Ganges Canal before the point of saturation was reached. The assumption that a given current is always charged with the full load of solid matter that it is able to carry has been added to his statement, and is abundantly disproven.

PLANS.

Passing from theory to the practical question of securing the object definitely placed before us, which is to obtain plans and estimates for the improvement of the Mississippi, so as to secure a navigation affording a depth of at least 6 feet, at the lowest stages of water, from the mouth of the Illinois to Saint Louis, and 8 feet from Saint Louis to the mouth of the Ohio, the first inquiry is concerning the character of the navigation desired. Since the requirement specifies the lowest stages of water, it must be understood that the same or a greater depth is expected at all stages above the lowest. The lowest stage known does not occur when navigation is practicable in the section of river under consideration, being a consequence of ice-gorges above the point of observation, acting as dams in cutting off for a time the supply of water to the river below, which, therefore, drains out. Such abnormal occurrences cannot be provided against.

Taking the lowest stage to mean the lowest occurring when navigation is not suspended by the rigor of the season, the obtaining of the depths specified at that stage does not necessarily imply the existence of that or a greater depth at all higher stages; for, as has already been stated, the channel depth sometimes increases as the river falls.

The depth of a river depends upon the form as well as upon the area of cross-section, and a large area may, from immoderate width, afford less depth than a smaller but narrower section—a consideration of great importance in determining the plan of improvement.

Another requirement of improved navigation is, that it should be reliable. The possibility that an improved navigation, after being available for one or more seasons, may deteriorate, would forbid the investment of capital in floating stock and the other facilities requisite to the transaction of business. Commercial relations are so extended and delicate, that an inferior and more costly route of transportation will be preferred to one having the advantage in these respects, but which cannot be relied on for future engagements. This quality being in some degree wanting in the Mississippi route, is one of the principal reasons why the business of transportation upon this route has not kept pace with the development of the territory it drains.

The demand, then, is, first, that a good navigation be obtained; second, that it be maintained.

The magnitude of the river and of the interests at stake, which occasion the demand for its improvement, measure, the one the task, the other the means of accomplishing it. How great these are it is not the design here to consider, but it is assumed that they are in due proportion, and that the only questions before an engineer are, what can be done, the plan of operation, and the mode of conducting these operations.

The first demand, that a good navigation be obtained, is satisfied with depth of channel. Combined with the second, that it be maintained, the continued existence of the channel is required, or the provision of ample and efficient means for its restoration, whenever impaired, so quickly, that practically no interruption shall occur. The first alternative implies permanent works; the latter may be satisfied by temporary.

Many persons, as before adverted to, hold to the opinion that attention should be confined to the amelioration of the low-water channel, as it defines itself year by year. Therefore, a consideration of the various modes of effecting a temporary benefit is necessary to a fair discussion of the subject before us.

The effort for this purpose must be directed to opening a passage through each bar as required, and as the bars or reefs are comparatively short in the direction of the channel, it is supposed that all that is needed is to make through the crest of the reef an opening wide enough for navigation, and that the increased strength of current will keep it open for the remainder of the low-water season. If it were possible to consider the reefs as abiding in nearly the same position throughout a season, this mode of opening a channel would be simple and apparently easy; as the appliances used, after accomplishing the end at one locality, could be moved to another, and thus, in succession, a single equipment would answer for a considerable extent of river. But as the sand reefs have a progressive motion, in many cases oblique to the line of deepest water, the channel is crowded out of its first position, and a new crest is formed, a process which can repeat itself many times in a season. This tendency, in connection with the shifting of the channel already mentioned, as attending decrease of volume, will make frequent returns of the equipment to the same locality necessary, and instead of maintaining a good navigation over a long extent, it will be found in practice that, to be effective, an equipment would find full employment upon two or three crossings, and while an opening is being made the appliances must occupy the channel, which is a serious objection. In order that these opened passages may maintain themselves, it is necessary that the additional area obtained in the channel should be compensated by the filling or obstructing of an equivalent area from some other part of the cross-section, outside of the channel; otherwise, we expect the impossibility that a certain volume with unchanged or increased velocity should fill an increased area.

These remarks apply with equal pertinence to two classes of appliances, viz, scraping, dredging, or agitating machinery, and portable dams. Comparing the merits of these classes of devices, the advantage would be in favor of portable dams in first cost and operating expenses. Both classes have been tried, and have demonstrated their ability to open a way through a reef; but the results have not been satisfactory, hitherto, because not lasting. It may be objected to this statement, that the perma-

nency of channels opened by portable dams has not been tested, as the only extended series of experiments on the plan of opening bars has been with the Long scraper; but it must be admitted that the permanence of an opened channel cannot depend upon the means by which the opening was made when the means are removed from the scene. The competition between devices for this purpose is limited to cost and efficiency in opening, and it is not the purpose here to discuss the relative merits of devices, but to consider the results which may be attained by their use. Experience indicates that to maintain a channel in this way would require an equipment for each section of 10 miles; to be kept in active operation during the low-water season of each year for all time; and the results then uncertain, and a serious disadvantage attending the application of the system.

A permanent improvement must of necessity be designed and executed in entire harmony with the natural laws of the river. A mighty river is impatient under restraint, can be led, but not driven. In one sense the difficulty of executing a plan of improvement increases much more rapidly than the size of the stream; in another sense, the potent forces, judiciously handled, can be made to do no inconsiderable part of the work.

Permanent works may be considered as serving a two-fold purpose: First to obtain and maintain a good navigable channel; second, to protect the adjacent lands from erosion and overflow. The navigation interest is without question the only one now to be considered; but the landed interest will certainly derive important incidental advantages from the permanent improvement of the channel.

The maintenance of a good navigable channel requires—

(1.) Sufficient depth at all stages.
(2.) A judicious location.
(3.) Stability in position.
(4.) Facility of approach to landings.
(5.) Easy changes of direction.
(6.) Moderate velocity of current.

These requirements stand above in the order of their importance. The first is a condition precedent, and must be satisfied. In solving the problem of securing depth of water, we have to deal with certain elements, all to some degree variable, either naturally or artificially, and the combination of the whole fixes the depth at any given time and place. These elements are width, volume, and velocity, and the latter term depends upon the slope or descent, and distance, as its controlling elements. Of the terms of this function the slope is fixed naturally, if we compare the elevations of geographical points connected by fixed lines; but if the length of the lines can be varied, then to that extent slope is an element subject to control; also the same result may be reached by producing a different distribution of the fall. To deepen a channel, by changing its slope, would be equivalent to lengthening the river. (The change of distribution of fall involves its concentration by dams, a method clearly inapplicable to a large silt-bearing river.)

Volume is an element which, for periods of time, is fixed naturally; but the discharge may be distributed artificially, so as to be more nearly uniform than the supply. The proposition to feed rivers at low stages, from reservoirs filled at the higher, is practicable with small streams, but for large rivers the areas required for reservoirs, and the cost of retaining-dams, become so enormous as to render the proposition impracticable.

The element of width is so evidently within the range of control, that no argument is required to establish the position, that contraction of widths is the most practicable mode of increasing the depth of channel in all cases where the volume is practically beyond our ability to control; in some cases, in addition to contracting width, it would be advisable to lengthen the channel. It will be seen that shortening must be avoided, as a rule; for the effect of a shortened course is to increase the slope and velocity, which would require an inordinate contraction of width to obtain the desired depth, and the increased velocity would endanger stability.

The second requirement, the judicious location of the improved channel, includes the purely engineering consideration of following the natural tendencies of the river, or at least the negative proposition, that no unnatural changes of position should be made, or unstable natural conditions be accepted; and also due consideration of the convenient use of the channel for all the purposes incident to navigation and commerce.

In the consideration of this topic, we come in contact with many local and individual interests; also with the opinions of many persons who have from observation and reflection arrived at fixed opinion concerning the course to be followed. Conflict with the former is to be avoided as far as possible. The latter may be considered, but cannot be allowed to govern. There are two opinions (held by many who glory in calling themselves practical men, and delight to cast contempt upon what they call scientific theories) which have their foundation in very poor theory, because unscientific. One is that the channel should be straightened and canalized; the other, that it should, in all cases, be held along the foot of the bluffs, where such exist. Without entering into any extended discussion here, it is proper to recognize the existence of these opinions, and state briefly why they must be rejected.

The logical objection to straightening the channel has already been given—the velocity would be increased thereby—thus rendering an inordinate contraction of width necessary to secure the desired depth of channel, and increased destructive energy will be brought to bear upon the banks and bed. It may be said that such increase of velocity would be temporary, as the river would adapt itself to the new condition, and in time regain its former slope. This can only be done by regaining its original length, or by a lowering of the bed, proceeding from the lower part of the river toward the upper. But where the bed is composed of material too hard to be readily moved, the accumulated fall must produce a rapid. The cut-offs that have taken place in the Lower Mississippi have not permanently shortened its course, and many which were made in Europe, especially upon the Rhine and Danube, with the purpose of shortening the distance between points of commercial importance, have defeated that design, by creating a current which proves a serious obstacle to ascending boats; and the lowering of the level in the reaches above the cut-off develops many new obstructions, while the deposits in the pool below caused similar difficulties there. The idea of the advocates of straightening is that, with a shorter course, flood-waters will pass without entailing injury, and that the increase of current will not impede steam navigation in a greater ratio than would be compensated by the decrease of distance.

The suggestion that the channel should be made to follow the bluff, is made simply because the bluff presents an unyielding bank, against which it is supposed to be an easy task to hold the current. As the bluff lines are very straight this proposition is similar to the first-mentioned and liable to the same objections. To hold the river to straight lines would be a work of great difficulty, and the difficulty would increase with increased velocity. One fear entertained by those favoring the bluff-line is, that if the channel be allowed to make a sweep out into the bottom it cannot be controlled, forgetting that it is easier to control a current following its natural course through alluvial soils than it would be to force it from that course by works which must rest on the same unstable foundation as the lighter structures required to restrain it within reasonable bounds. Another consideration, which would be fatal alike to both propositions, arises from the disturbance of existing business relations by the destruction of landings, which must result from their adoption. Moreover, if the bluff is followed, the landings would be chiefly limited to the side whose broken character forbids the expectation of much agricultural produce being raised; and, in any case, the landing would be difficult of access from the back country. In addition, the opposite alluvial side would be cut off from access to deep water almost entirely.

Existing business relations have adapted themselves to the natural course of the

channel; and, in order to avoid individual claims for compensation, it will be necessary to make the improved channel follow the natural course as far as possible, on the principal that riparian rights and benefits which have been destroyed or changed by the action of natural causes furnish no ground of claim in equity if the privation be rendered permanent.

Policy, then, would determine the advisability of following the existing channel in all cases, and the same course would logically follow from a train of scientific reasoning, for the law of a stream is the expression in general terms of the facts presented in nature. To reconstruct the stream according to conditions imposed or assumed, can be done successfully if we know all the facts and relations which enter into the problem. The omission of one may be fatal to success; hence all arbitrary changes are to be avoided. But nature overlooks nothing, and we may confidently assume that the position and direction of the river at any time is the resultant of all the forces, and consequently is a concrete expression of the law of the stream, which we may modify and preserve, but may not safely destroy or radically change. To accept and follow nature is, in this case, the beginning and end of science. To attempt either to straighten the river or to compel it to follow the rocky shore would be alike presumptuous.

The third requirement—stability in position—is a natural consequence of permament improvements, and essential to the establishment of facilities for the traffic. To insure this quality it is necessary that the velocity should be sufficient to carry the lighter material brought into the channel to a suitable place for deposit, but not great enough to cause erosion of the bank.

The fourth requirement—facility of approach to established landings—is an important consideration, and since large towns cannot follow the river in its changes, the conditions presented are often antagonistic to the natural bent of the channel; and in such cases the demand is absolute that the natural be changed. At times the conditions border upon the impossible. Take, for instance, the case of a town situated upon the convex bank of a river; it is well nigh impossible to maintain the channel on the convex side, because unalterable natural laws forbid. If we try to contract the width to such narrow limits as to obtain a required depth on the non-channel side, which is the best, and, indeed, the only thing that can be done, we endanger not only the works themslves, but also the property, and lives even, of the people when the waters of a mighty flood demand passage through the narrow gate-way; and no safe contraction can assure the desired depth on the convex side.

The fifth requirement—that changes of direction should be easy—is mainly in the interest of stability, but also has a practical relation to the convenient use of the channels. A discussion of the bearing of the direction of currents in relation to the banks, if entered into, would exceed the limits of this report. The result reached would be, that the current should be parallel with the banks whenever possible and abrupt changes of direction avoided. Practically it would not be proposed to make many changes in the present contour of banks by active interference, but rather to secure a favorable alignment when it exists; and when it is imperfect to patiently wait for nature to work out the problem of a good line. Accurate surveys of stable beds will determine the degree of curvature most favorable. When the character of the soil does not furnish sufficient resistance some form of artificial protection must eventually be resorted to.

Particular pains were taken to survey and delineate upon maps the strongly-developed curves or bends known as Rush Tower, Saint Mary's, and Cape Girardeau, the latter being considered a good example of a curve of stable regimen. These three curves, if carefully studied by means of re-survey for several years, may develop laws the knowledge of which will be of the greatest importance in conducting the improvements of the river.

The fact that the natural course of a river flowing through an alluvial bed follows a series of direct and reverse curves, merging into each other, is universally admit-

ted by all engineers of study and observation, and the expediency of maintaining them in such course, where local interests of magnitude do not demand and warrant departure, is equally admitted.

A cross-section in a bend will generally approach in shape a right-angled triangle, the right angle at the bottom and near the concave bank. Consequently, in a bend, the width may be greatly increased beyond that admissible for straight portions of the river, yet maintaining nearly the same area of cross-section, and sufficient depth in the channel. In bends, therefore, protection of banks is the improvement required.

The sixth and last requirement—moderate velocity—has been discussed incidentally already. There are localities, especially below Commerce, where the velocity is at times excessive, but beyond possibility of being changed for the better. The condition must be accepted and met by stronger works to insure permanence.

Having in the preceding discussion shown that a system of temporary expedients would fail to secure the end, and also defined what a permanent system would accomplish, the question arises, Can the superior permanent system be carried out upon such a river as the Mississippi? In answering this question we have the benefit of the experience of European engineers, who have successfully improved silt-bearing rivers traversing alluvial valleys, and subject to great variations of volume, and the Mississippi differs only in degree from some of these successful precedents. That this difference in degree does not present insuperable difficulties, is proven by actual experience in works of the character proposed, executed during the last three years upon the Mississippi, which have proved successful.

The problem, then, is solved as an engineering question; the execution is a question of time and money.

The adoption of the permanent system is but a question of time; for, as the country becomes older and more densely populated, aside from the requirements of navigation, the products of the fertile alluvial lands will be essential to the welfare of the country, and the state reasons which have led to the regulation of European rivers will demand the same for the Mississippi, and, in time, its principal tributaries also. The completion of these works will require many generations; but as the necessity is clearly foreseen, it would be inexcusable to ignore it now, since it is entirely practicable to make every step in the interests of immediate wants a step also toward the final end, without adding to the cost or delaying the realization of the benefit desired. Assuming that this course is to be pursued, it remains to consider the steps that come first in the system proposed, and which will be the work for the years immediately before us.

In the interest of navigation the improvement of the worst bars is first demanded, and this consideration decides each year the points where work is to be done. As the worst bars now are at or very near islands, or high bars that are as effective as islands in dividing the waters, the most useful work at present is the closing of the chutes, which, we may be confident, will materially help the navigation, as the cases are rare where a serious obstruction occurs when the water all flows in a single channel. After the closing of the chutes the contraction of width in wide reaches comes as the next step, and, when complete, good navigation is obtained, and must be maintained by the protection of caving banks.

The closing of chutes often involves more or less conflict with local and proprietary interests, and in some cases with matters which rise into the importance of state questions. The definition of the boundaries of States by the channel of the Mississippi gives the jurisdiction over islands to the States to which they belonged at the time the boundary was defined, as decided by the United States Supreme Court in the Wolf Island case (Missouri *vs.* Kentucky, Wallace's Reports, Supreme Court United States, volume 11, pages 395–411). Several cases are known where the present channel divides the island from the State to which it belongs, and if the old channel, now but

an insignificant chute, is closed, the island will be territorially annexed to a State having no jurisdiction over its soil. It will readily be seen that serious complications may arise in such cases. Such annexations are likely to occur from natural causes, and several will necessarily be made if the improvement continues, and the closing of chutes is to be determined upon engineering considerations alone.

It may not be out of place to mention here the general belief prevalent among owners of land adjacent to island chutes that the construction of a dam across the chute or slough will insure accretions of land to their benefit.

This is true to some extent. In the case of a single dam, the accretions generally take place in the shape of a bar across the foot of the slough or chute, another in the prolongation of the island, and a deposit at the head of the chute, extending some distance above the dam, frequently neglecting, however, the immediate vicinity of the dam altogether. A high dam just below the level of ordinary sediment-bearing floods would insure more deposit, but experience on the river Rhine, where, in most cases the object was to make land, demonstrated the fact that three or more dams were generally necessary to insure sufficient depth and extent of deposit. In the case of a single low dam it was found better to locate it at a considerable distance below the head of the chute, in order to allow as much of the gravel and other material to enter the chute as possible, not only to aid in the formation of land, but in addition to prevent the material being swept into the channel.

The formation of land not being an object of present consideration, we may say that, as a general rule, low dams and dikes should alone be used. In general terms, none of the works erected should interfere with the free discharge at high stages, but should begin to act at some intermediate stage. This should be before the want of depth is felt, and will probably vary for different localities.

The meaning of the words "intermediate stage" in the last paragraph require definition. The idea is, that the dikes and dams should be of such height as to produce action upon the bed when the river is first approaching the low stage, so as to prepare the channel, in some degree, for the less powerful effect of the diminished low-water volume. Yet it must not be inferred from this that violent action upon the bed is by any means advocated.

As before stated, the path of the heavy materials of floods is generally along the most direct course. The low water having to cut for itself a channel, seeks the line of least resistance, through the lighter and softer material, and this is one reason why the low water channel is, in nature, more tortuous than the high.

Referring to what has been said on the subject of the partial filling of the bed at high water, and the principle universally accepted that depth of channel is easiest secured by contracting the width, the query arises: Is it not possible to retain the high-water deposits over a part of the width in place as the water falls, and thus contract the width at low water? Two modes of accomplishing this suggest themselves: first, to protect the areas which it is desired to convert into dry bars by inclosing them with barriers quickly and cheaply constructed; second, by attacking the crests of the reefs upon the line it is desired to have the low-water channel follow, and thus concentrate the scour upon that part of the bed which is to be the low-water way. In practice it might be found advisable to combine the two methods, and thus open a field for the use of some of the devices discussed under the head of the temporary system.

If, on trial, these suggestions should be found practicable, the benefits to navigation which would follow a regulation of the river could be more quickly and cheaply attained than in any other way, for we have but to secure the areas laid dry from being washed away, and the opposite bank from caving, to render the improvement permanent. Treated in this way, the immediate and temporary improvement would be entirely consistent with the system of permanent improvement.

In constructing dikes and dams upon the unstable foundations found in the Mississippi, the difficulties to be encountered are the strength of the current and the liability of scour around and under the works during construction and after completion. The

strength of the current is a difficulty to be overcome, and must increase with the progress of the works until they arrive at or near the surface of the water. The scour must be arrested at an early stage of the work, or the additional expense incurred of placing foundations in deep water, and of the greatly increased prism of material required to reach a determined height. Settlement of the works during construction and even after completion is to be expected.

Various modes of construction have been tried and most carefully studied, and decided preference is given to the general plan of brush foundations and riprap superstructures as adapting itself to any shape of bottom, and being able to endure settlement without injury. Brush foundations, besides flexibility, have the merit of distributing the weight of superstructure over a considerable area, while the body of brush presents, when compacted by the superincumbent weight, small interstices for the passage of water close to the bottom. This material being found in large quantities along the river, can be obtained and handled at moderate cost. Extended operations would soon exhaust the present supply, and it may be found advisable to encourage the growth. Under moderate appropriations the natural production would probably suffice.

Material suitable for riprap is obtainable at many points along the river, insuring its procurement at very reasonable rates. It would be good policy for the Government to acquire, by purchase or long lease, several quarries, to be operated under contracts or by hired labor, as may be found most desirable.

In construction the utmost rapidity of progress is essential to economy, and it has been found practicable to carry the foundations across channels and bars so rapidly that no considerable deepening took place as the work advanced, by limiting the first work entirely to putting in an apron to protect the site of the proposed work. In closing chutes, this class of work must be done when the river is at a low stage, and in any case cannot be done when drift is running. This limits the possibility of preliminary work to the fall season, and renders any loss of the favorable season a serious disadvantage. The postponement of appropriations to the close of the session of Congress is unfortunate in that every alternate year a considerable part of the season is consumed in preliminaries, a loss which could in a measure be avoided if the amount to be appropriated could be certainly known as early as March of each year.

As already intimated, it is not practicable to present plans in detail owing to the great changes which must occur between the time reports are made and the commencement of work. In so extensive a field as the Mississippi, from the Illinois to the Ohio, the simultaneous prosecution of works at all the points where improvement is desirable is not possible under the system of yearly appropriations, but might be done if the full amount estimated were granted at once. As this course is not supposed to be possible, it is contemplated to prosecute the works in the order of their importance to navigation, selecting those places which present the most formidable obstructions for the first operations, the number undertaken each year depending upon the extent of work required at the several places and the means available.

The estimate of this report is based upon the present condition of the river. It is probable that some of the items included in the estimate will be found unnecessary, the desired end being reached naturally; others not estimated will as probably be found necessary; it is, therefore, thought best to name the aggregate sum for each locality, without specifying the items of the estimate. As the estimates are made upon the basis that certain lengths of dams and dikes will be required, and at a cost per unit, taken from the actual cost of such works already constructed, the aggregate cost will probably not be materially changed by the changes in the position and length of individual proposed works.

The list of localities is not final, if we consider the probability, almost certainty, that new obstructions will be developed hereafter. The estimate given by localities may be taken as the cost of obtaining the navigation desired. To maintain that navigation will require the revetment or other protection of caving banks. The esti-

mated sum of $4,000,000 is intended to cover the cost of such works—to preserve the channel at those points where the necessity is likely to occur.

Further examination would be necessary to determine where works of this character are most needed. The greater part we may safely say would be required between Commerce and the Ohio.

ESTIMATE.

From the Illinois to the Missouri River	$600,000
From the mouth of the Missouri to Saint Louis	150,000
Upper section of Saint Louis Harbor	185,000
Arsenal Island	100,000
Horsetail Bar	100,000
Twin-Hollow Bar	80,000
Platin Rock	72,000
Selma	110,000
Fort Chartres	75,000
Turkey Island	100,000
Saint Genevieve	100,000
Liberty Island	100,000
Hat Island	150,000
Grand Tower	50,000
Hanging-Dog Island	30,000
Moccasin Springs and vicinity	200,000
Devil's Island and vicinity	250,000
Hamburgh	50,000
Commerce and vicinity	200,000
Buffalo Island	20,000
Greenleaf's	150,000
Add 10 per cent. for contingencies	287,200
Revetment between the mouth of the Missouri and mouth of the Ohio Rivers	4,000,000
Total estimate	7,159,200

In the conduct of operations upon the treacherous foundations which characterize the Mississippi, economy and success demand that the engineer in charge should have entire liberty to modify his plans whenever necessary, and to have full control over his work; to push forward when occasion demands, and to suspend when it becomes desirable so to do.

Contracting works of this character is attended with serious difficulties; first, because all estimates are necessarily indefinite and uncertain; under varying conditions the character of work is liable to change, in the kind, proportions, and amount of material used, and what was expected to be easy may become difficult, or anticipated difficulties may disappear. These contigencies render it very difficult to frame specifications that will meet the practical conditions, and bids must be made at a venture, which demands a wide margin in prices beyond what a definitely described work can be done for. Under such conditions the result of a letting, under existing regulations, is almost inevitably to give the award to irresponsible parties, the guarantees and bonds which satisfy the requirements affording no sufficient security. Experience has shown that, with an inefficient or tricky contractor, works of this character are very expensive, for delay or neglect, intentional or not, results alike in vastly increased quantities of material; and as the plans contemplate the placing of foundations in water of moderate depth, the suspension of work for a few days will produce a local scour exceeding the depth provided for, and compelling resort to more expensive methods not provided for in the contract.

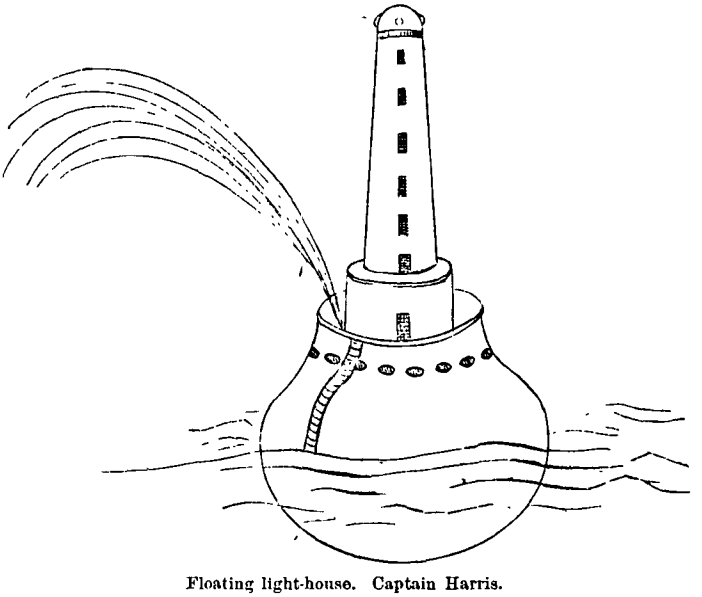
Considering the matter in the light of experience, I cannot recommend the contract system, so far as the preliminary work of aprons and foundations is concerned. After

these preliminaries are secured there is no objection to adopting the contract system for the delivery of material in the body of a dike or dam. Necessity has compelled me to provide the plant required for the construction of these advance works, and, working under small appropriations, this plant suffices to do all the work; and, it being unquestionably good policy to keep equipment fully occupied, the work hitherto has partly been done by the United States directly by hired labor and the purchase of material in its natural state. Although compelled, by act of Congress, to pay 25 per cent. advance upon prevailing rates of wages for labor, the results show no increase of cost over the prices formerly paid contractors for material delivered in place; and all the work and workmen being now in immediate control of the engineer in charge, he is made responsible for the success of his operations.

This system has been found to work well; no serious mishaps have occurred, and the work is done more cheaply than before, though, in part, this may be attributed to improvements in the method, and experience in their application. Contrary to the prevailing impression, that faithful labor cannot be obtained from men directly employed by the Government, the amount of work done compares favorably with that accomplished by equal numbers working for a contractor. Faithful labor can be had under faithful overseers and foremen by any employer, and with unfaithfulness or inefficiency in the higher grades no employer can secure faithful service.

FLOATING LIGHT-HOUSES.

To increase the value of a light-house it is frequently pushed far out to sea and built with great labor, expense, and sometimes loss of



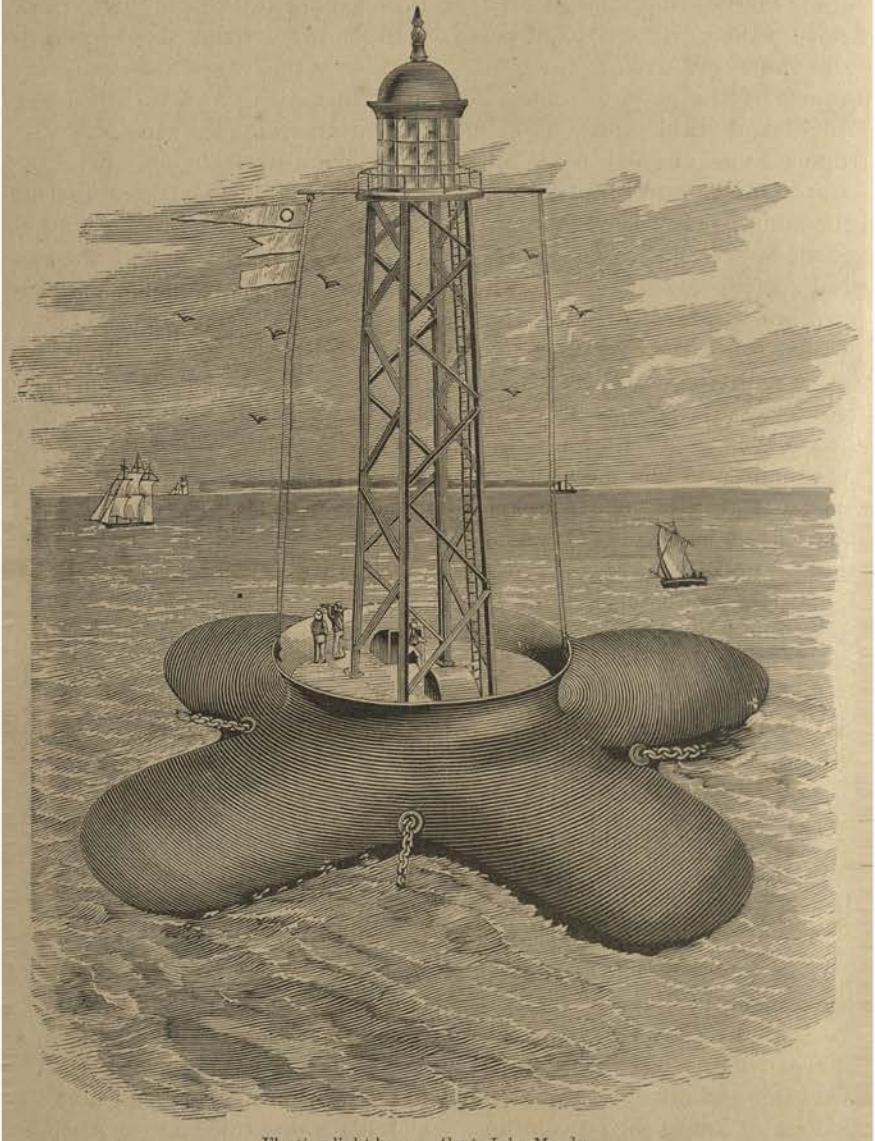
Floating light-house. Captain Harris.

life on a barren rock or a shoal, the desire being to give vessels the warning of danger as soon as possible.

In many localities, light-houses cannot be built; their place is then taken by light-ships, beacons, bell and whistling buoys, &c. These are im-

perfect substitutes, none of them being able to throw the warning light or sound to such distances as the light-house with its accompaniment, the siren.

In this exhibition there are several methods shown by which it is proposed to place light-houses where they would do the most good, the



Floating light-house. Capt. John Moody.

underlying principle of all being the same, namely, to put the light-house on some kind of a float which would be comparatively steady, be securely anchored, and able to withstand any storm.

Before describing the methods, it may be as well to note some of the advantages claimed and uses to which the light-house could be put. They could be anchored anywhere on the high seas, and both guide and light vessels to their destination. One inventor represents his light-houses strung across the ocean like street lamps in a city; they could be used as post-offices, telegraph, signal, and life-saving stations. Pilots could await on them the arrival of vessels. In stormy weather ships could tie up to them and outride the gale. All these advantages and more are claimed by the inventors for a floating light-house which would be permanent and stable and exhibit models and drawings showing how they propose to accomplish these most desirable ends.

Capt. R. H. Harris exhibits a large painting, showing three floating light-houses and some vessels in a storm, the vessels are very much tossed, but the light-houses are quite steady, and are assisting the vessels by firing rockets and throwing life lines from mortars—the float is a can buoy of large size.

Capt. John Moody's float is also of wrought iron and has four rays or arms, these being primarily intended to steady it and could be used for storage purposes. It is also claimed that this form allows the light-house to be boarded at any time and in any weather. In war times it is proposed to arm the float and use it as a fort.

Mr. H. B. Stone shows two models. The flotation is purposely hidden for fear of having his idea stolen. As well as could be ascertained his light-house was swung on gimbals and heavily weighted below and supported on a circular, hollow, wrought-iron ring, the idea being that the ring would move independent of the tower supporting the light. No allowance seems to be made for the action of the wind.

In the words of one of the inventors, "The undertaking is certainly great, and to carry it out in a series of vessels across the Atlantic would cost a great sum of money."

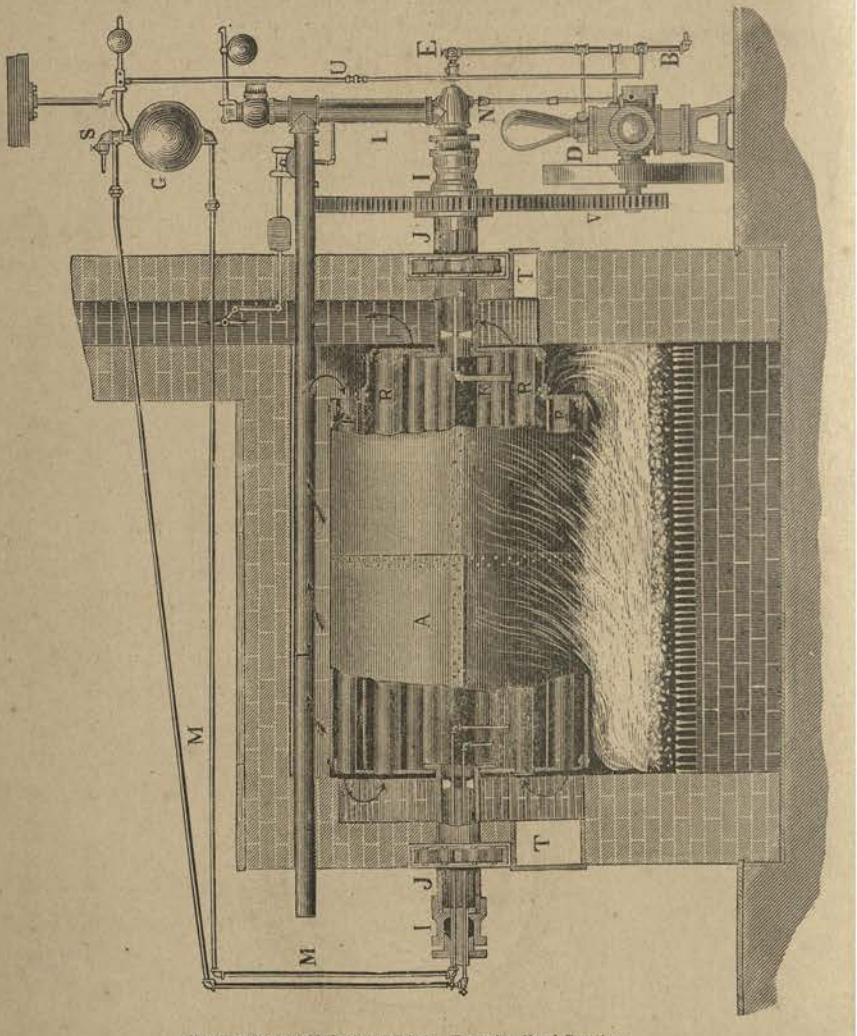
II.—MECHANICAL APPLIANCES.

BOILERS.

THE PIERCE ROTARY TUBULAR BOILER.

This boiler is a cylindrical, tubular boiler, suspended on axes and capable of rotation; it has two circular rows of tubes running from end to end. The outer row is nearly surrounded by buckets or elevators so constructed as to partially encircle them and keep the tubes submerged in water and also to drench the inner surface of the boiler shell above the water line at each revolution. The inner row of tubes acts as superheaters for drying as well as generating steam. The boiler is incased in brick-work, and rests on trunnions; the water is received through one trunnion and the steam withdrawn through the other. The boiler is rotated about once a minute by shafting or by the steam pump which feeds the boiler. The entire boiler being surrounded by fire, the con-

traction and expansion throughout will be equal, and there can be no corrosion from contact with masonry. The rotation of the boiler insures a constant and thorough circulation of water, thereby facilitating the escape of steam as fast as generated.

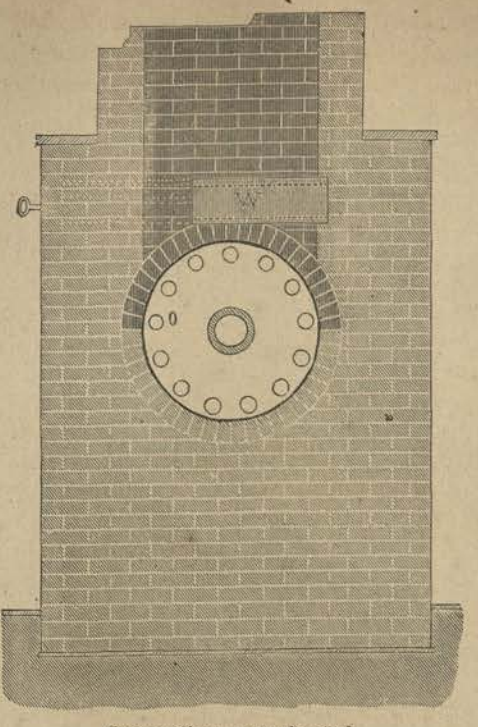


Pierce Rotary Tubular Boiler.—Longitudinal Section.

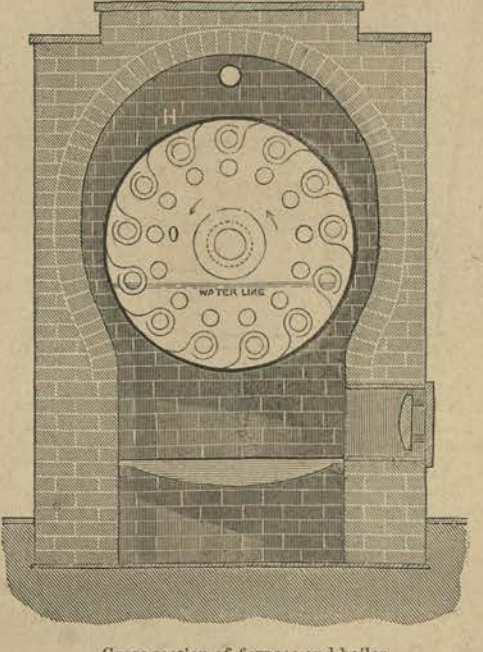
A.—Boiler shell. B.—Suction pipe. D.—Pump. E.—Check valve. F. F.—Outer row of tubes. G.—Water-line regulator. H.—End view of boiler. I. I.—Packing boxes. J. J.—Trunnions. K.—Feed-water pipe. L.—Steam pipe. M. M.—Water-regulator pipes. N.—Steam pipe to pump. O.—Tubes and buckets, end view. P.—Damper regulator. R.—Inner row of tubes. S.—Air pipe to water-line regulator. T.—Doors to inspect ends of the boiler. U.—Rod regulating feed water. V.—Gear for rotating boiler. W.—Damper at chimney flue.

The advantages claimed for this boiler are economy of fuel, great steaming capacity, safety, durability, and rapidity in generating steam.

Made by the Pierce Rotary Tubular Boiler Company, 95 and 97 Liberty Street, New York.



Cross-section near smoke-stack.

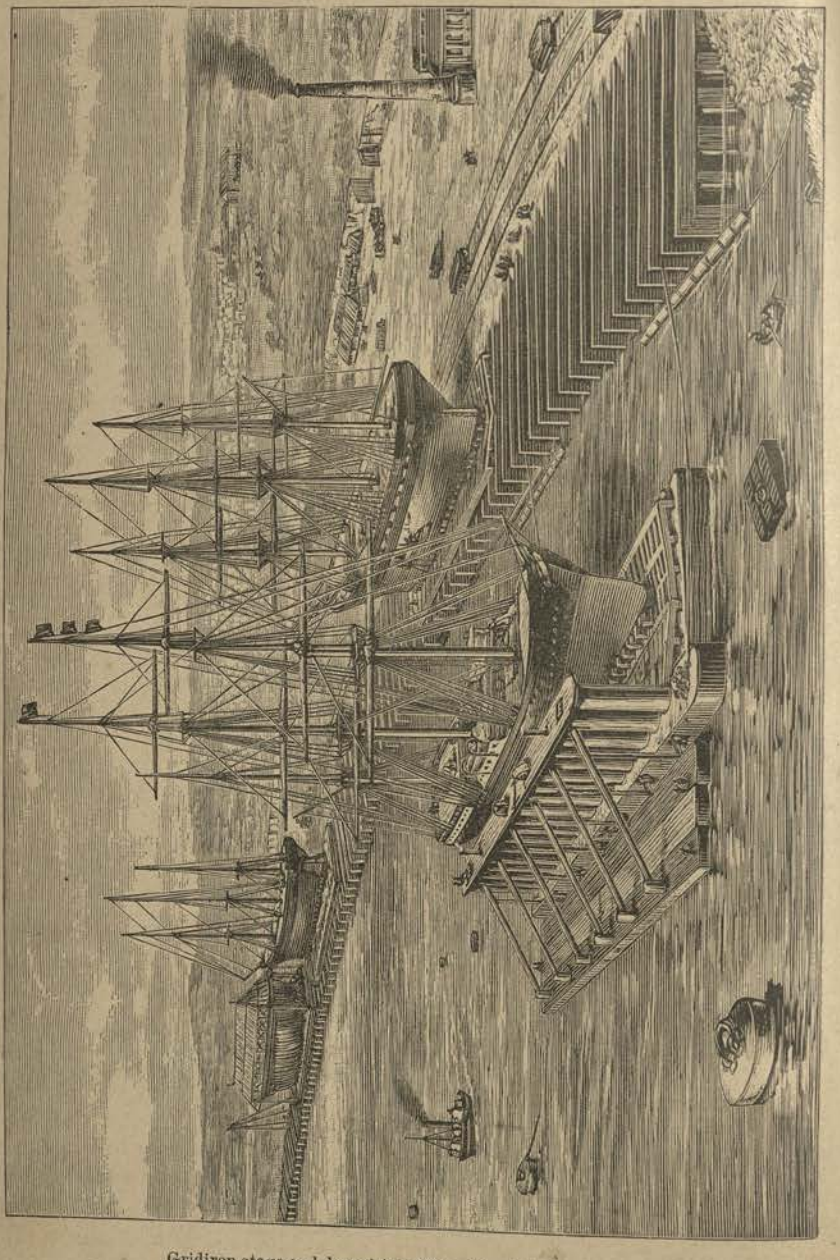


Cross-section of furnace and boiler.

DOCKS.

FLOATING DOCK.

(Invented by Clark, Stanfield & Co., Westminster, England.)



Gridiron stage and depositing dock.—Clark & Stanfield.

This is one of the most efficient and least costly of the numerous plans for floating docks, and, though quite recent, has attracted the attention of several Governments.

A large dock on this principle is now being constructed for the accommodation of the circular iron-clads of the Russian Government, as well as of their iron-clads of the ordinary form; this dock is intended for the port of Nicolaieff.

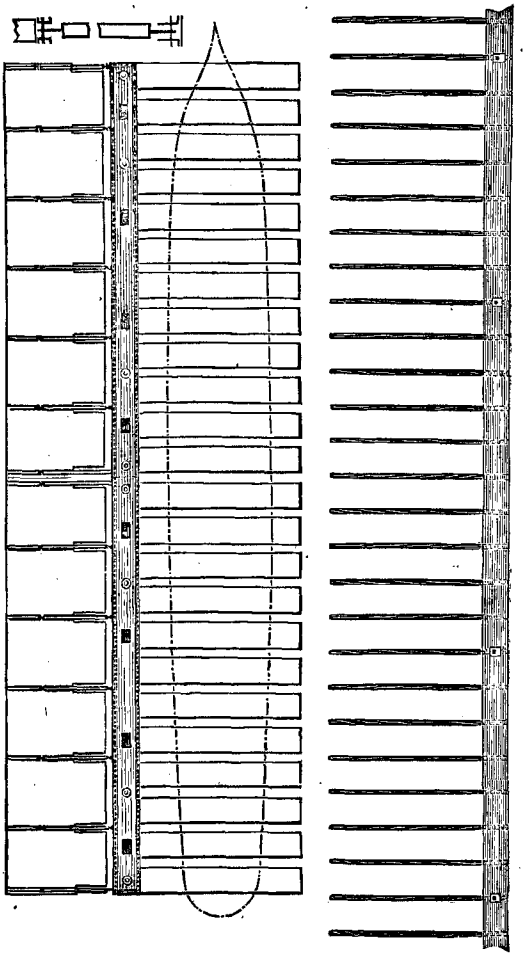


FIG. 1.

On reference to the diagrams it will be seen that the plan, Fig. 1, represents several rows of piles (the upper surface only of which can be seen in this view) driven parallel into the shore, and having between them a clear space of water; a side view of one of these rows of piles is shown in Fig. 4. These piles constitute the gridiron staging from which the dock is named. The operation of docking is as follows: The

dock is lowered by means of letting water into its pontons, or fingers (shown in plan in Fig. 1 and inside elevation in Figs. 2 and 3) to a sufficient depth to allow the vessel to be brought over it, as shown in Fig.

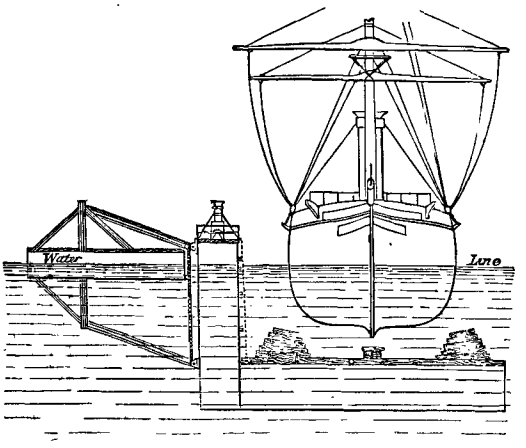


FIG. 2.

2. In this position the side of the dock has a freeboard of several feet; the water is then pumped out of the pontons by means of powerful centrifugal pumps carried in the upright; this causes the dock to gradually and very steadily rise with the ship on it, as shown in Fig. 3; the dock with the vessel is now hauled into position opposite the staging, its pontons passing between the parallel rows of piles, and, the vessel being

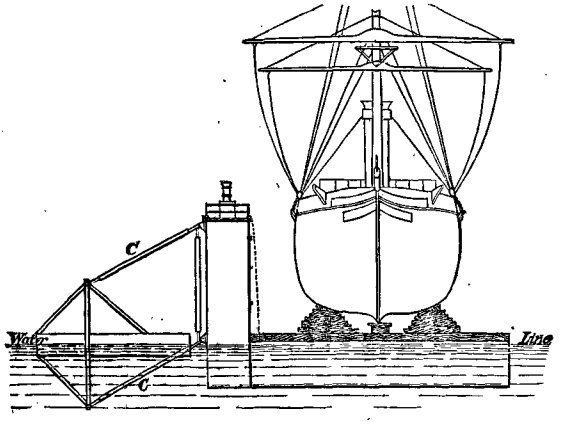


FIG. 3.

clear above them, a little water is now admitted to the pontons, causing the dock to be lowered, and shifting the bearings of the vessel from the pontons to the staging without any rolling, sliding, or other such movement; the vessel is of course now supported on another set of blocks, as shown in Fig. 4. The dock, being clear of the vessel, is withdrawn from

the staging, and is now at liberty to lower a vessel into the water, or deposit another on some other part of the staging, which may evidently be of indefinite length.

The outrigger balance shown in Figs. 1, 2, and 3, is attached by a

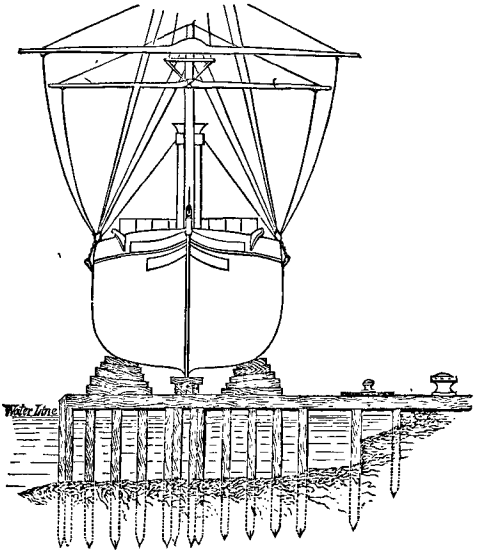


FIG. 4.

parallel motion to the side of the dock (the form of joint is shown in Fig. 1); its use is to insure stability when a vessel is being raised or lowered. When the vessel has been raised, as in Fig. 3, the outrigger may be disconnected if there is any reason for doing so, such as taking

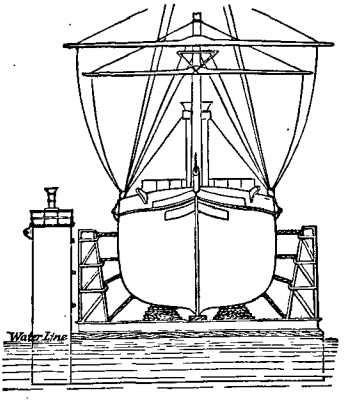


FIG. 5.

the dock through a narrow channel or entrance. It will be seen that the outrigger always floats, and that its movements are necessarily the same as those of the dock, so that any movement of the latter causes

the lifting out of the water of one side of the outrigger and the corresponding submersion of the other. The force requisite to cause such a movement, even through a small angle, is enormous, amounting to several hundred tons, but with ordinary management not more than a ton or two of this righting power is called into play, the valve engineer immediately rectifying any tendency to movement, as explained below. From the great width of the dock the whole structure when afloat is eight or ten times more stable than the vessel herself.

It will be observed from Figs. 1, 2, and 3, that the pontons of the dock are fixed to the vertical side at one end, but are left quite free at the other. The pontons are divided into several water-tight compartments, each of which communicates by means of a separate pipe with the valve-house. These pipes are divided into four groups corresponding to the four corners of the dock, each group being governed by a principal valve. In the valve-house is a spirit level by which the engineer in charge of the valves can see at a glance what tendency to movement the dock possesses; he at once adjusts his valves accordingly and so keeps the docks perfectly level. It must be borne in mind that the buoyancy of the pontons themselves constitutes the lifting power of the dock and that the side is not made use of for this purpose.

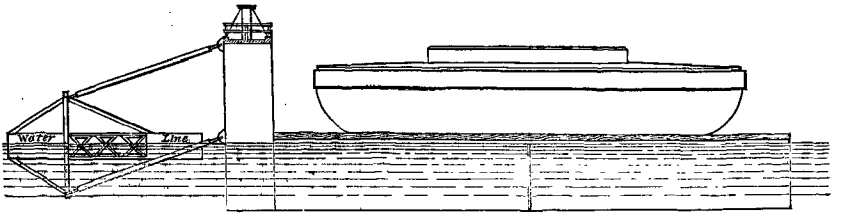


FIG. 6.

It may in some cases be an advantage to use a cradle on which would of course be carried the necessary bilge blocks, &c., and which would be transferred bodily with the ship from the dock to the staging, and vice versa. A special cradle, with side shoring frames for heavy vessels, is shown in Fig. 5; but an ordinary cradle is formed simply of a series of light cross iron girders.

The dock now being constructed for the Russian Government has one or two special features. Its length is 280 feet, divided into three portions, the two outer portions being 100 feet each in length, and the middle one 80 feet; the usual course would be to make the dock in halves, in every respect equal and similar; each portion, as is the case in this Russian dock, being complete in itself as a small dock, with all the necessary machinery, and being capable of docking the other portion for the purposes of cleaning and repairs. The pontons of the Nicolaieff dock, each 72 feet long, are not permanently attached to the side, but are interchangeable, so that they can be placed end to end, doubling the width of the dock, as in Fig. 6. It will be observed from Figs. 6, 7,

and 8, that the outrigger of this dock is made in the form of two parallel pontons firmly braced together; its total width is 45 feet, each ponton and the space between being 15 feet in width. Of course, each third complete portion of the dock includes its third portion of the outrigger.

In its ordinary form, with the separate portions connected in the same straight line, the dock is always ready for the accommodation of vessels of the usual proportions; but when arranged as in Figs. 7 and

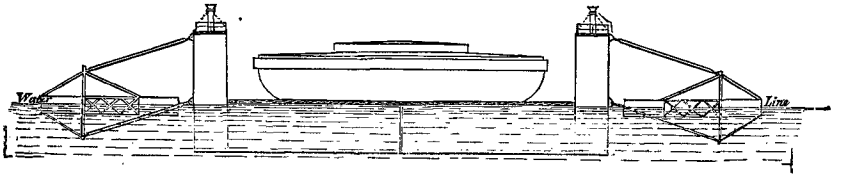


FIG. 7.

8, it is prepared for receiving vessels of circular or other special shape. This latter arrangement is due to his excellency Admiral Popoff, of the Russian Imperial Navy. In Fig. 6, the outrigger has been removed previous to depositing the circular vessel. On this system it is evident that a dock can be constructed for vessels of any width or diameter, however great, rendering them quite independent of the width of dock gates, &c. The Nicolaieff dock can take a vessel of as much as 140 feet in diameter, and, as at present formed, is suited for raising a vessel

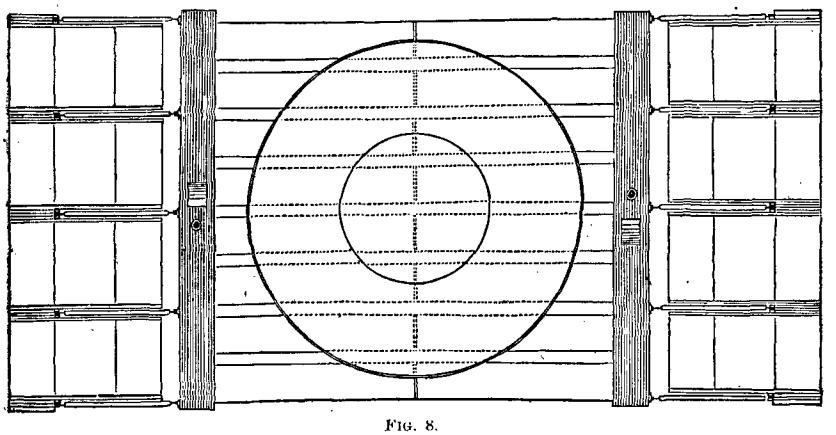


FIG. 8.

4,000 tons dead weight in about an hour, and is so constructed that by a small addition at any future time it can be made to lift vessels weighing as much as 10,000 tons.

A unique and valuable peculiarity of this dock is the readiness with which it may be increased as the necessities of a navy or the trade of a port may require. This is accomplished by putting in a third section between the two original halves of the dock without in any way alter-

ing the latter; the pontons of this section may be a little deeper than those of the original portions, so as to have greater lifting power if required. An important point is that the expense of this addition would be at the same rate per ton as the first cost.

The staging may be fixed in shallow places, thus utilizing much space that is at present almost useless. Only a few feet of water are required to float the dock with the vessel on it, it being necessary to have a greater depth in but one place, where the operations of raising and lowering have to be performed.

Docks on this principle could always be used for floating vessels over bars and shallows; they are also applicable for transporting trains across lakes and rivers.

The following are the chief points of this dock as enumerated by Mr. Latimer Clark in his paper recently read before the Institution of Naval Architects:

(1.) With one dock any number of vessels can be docked and deposited high and dry out of the water on wooden platforms, in a convenient position for cleaning and repairs, along the waste, sloping shores of a river or dock.

(2.) The provision of an additional length of staging, at a comparatively nominal cost, is equivalent to the building of an additional dock.

(3.) As the dock is used ordinarily for lifting vessels on to the stage, it can be kept at all times ready to receive disabled or other vessels, which can be at once deposited on a stage and the dock left free for further use, and in this respect has a great advantage over all other descriptions of graving-docks.

(4.) A vessel can be placed upon the staging, cut in two, and readily lengthened by lifting one-half further along the staging by means of the dock.

(5.) Vessels can be conveniently built on these stages on an even keel and launched without the slightest strain, and without the risk and cost of launching, and without occupying the space required for the formation of ordinary ship-ways.

(6.) Vessels, when on the dock or stages, are thoroughly exposed to the action of sun and wind, allowing paint to dry and harden rapidly, and affording great facility for examination and repairs.

(7.) The dock, with or without a vessel, may be readily transported from place to place, for the purpose of raising or depositing vessels at different points.

(8.) The dock will not, under any circumstances, sink, even if all its valves be intentionally left open.

(9.) One-half of the dock can be readily raised level upon the other half for the purpose of cleaning or repairs.

(10.) By the use of air, which may be stored in some of the cylinders under compression, a vessel may be raised, righted, and lowered again in less than an hour.

(11.) These docks, if constructed in the first instance too small for the requirements of trade, can be at any time enlarged to any extent at the same rate per ton as the original cost.

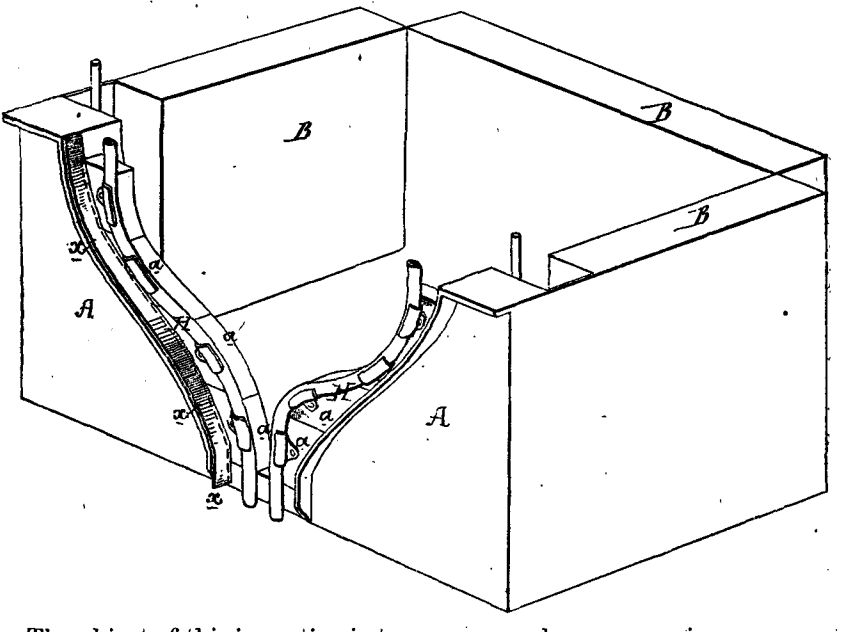
(12.) The docks are capable of receiving vessels of any size or length, or of a width too great to pass through ordinary dock gates; such, for example, as circular ironclads of 100 feet or 150 feet in diameter.

There is yet one more point which will be of interest, viz, the facility afforded by this system for laying up in ordinary, high and dry, vessels of any form or size. The life of a navy could be very considerably prolonged at great economy to the nation, without being rendered even temporarily unavailable, for a whole fleet could be lowered into the water at a day's notice.

IMPROVED END DOCK OR COFFER-DAM.

(Inventor, Frank Cox, 326 East Thompson street, Philadelphia.)

Fig. 1.



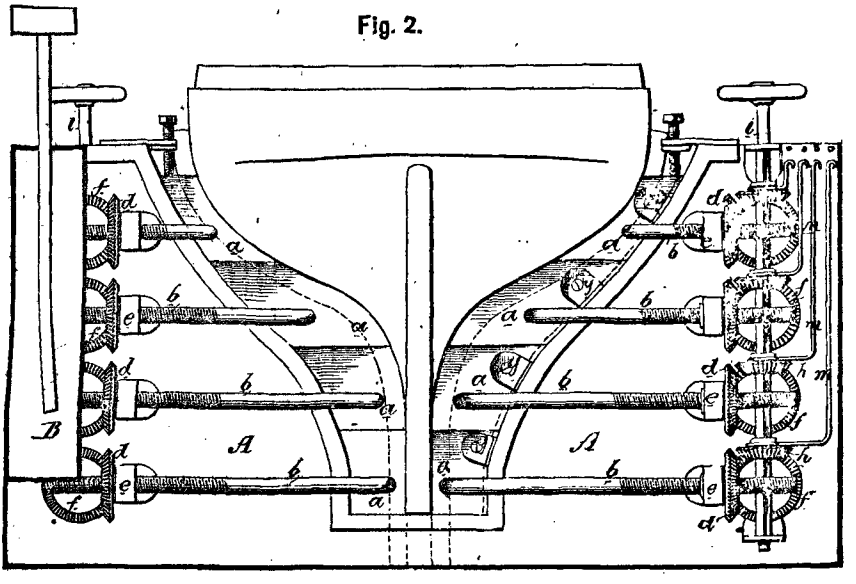
The object of this invention is to remove, replace, or repair screw-propellers without resorting to the expensive and tedious operation of dry-docking the vessels to which they are attached, and this object is attained by a floating coffer-dam combined with adjustable slides.

The coffer-dam consists of a square or oblong vessel open at the top but closed at the bottom, sides, and rear end, the front end having an opening somewhat larger than, and of a shape approximating to, that of the transverse section of the stern of the largest vessel to which the coffer-dam may have to be applied.

In the illustrations herewith A is the front end; B, sides and rear; *a*, slides; *b*, screw-rods; *d*, hubs of bevel-wheels; *e*, bearings; *f*, bevel-wheels; *h*, pinions on shaft; *i*, shaft; *m*, rods to raise pinions *h* in or out of gear; *x*, packing; *y*, set-screws.

At each side and at the rear is an air and water tight chamber, to which water is admitted when the coffer-dam has to be sunk and withdrawn when it has to be floated. To the front end of the coffer-dam, on each side of the opening for admitting the stern of the vessel, is adapted a series of slides, and to each slide is connected a screw-rod, the nut of which is the hub of a bevel-wheel, adapted to a bearing secured to the

Fig. 2.



inside of the front end of the coffer-dam. Each bevel-wheel gears into a like wheel, and the latter into a pinion on a vertical shaft which extends to the top of the coffer-dam, and is there worked with a hand-wheel or other suitable appliance. Each bevel pinion is so connected to a rod that by means of the rod it can be thrown in or out of gear with the other bevel-wheel.

In using the coffer-dam it must first be floated to a position near the vessel, to the stern of which it has to be applied, and then so far sunk by the introduction of water into the chambers that the coffer-dam can be introduced beneath the stern, adjusted in relation to the same, and connected to the vessel by suitable stays and guy-ropes, after which the slides must be moved forward by operating the shafts, until they are in contact with the vessel. As the ends of these slides cannot be made to fit snugly to the sides, there must necessarily be left open spaces which are closed by elastic packing strips, by preference made of rubber tubing, which are so connected to the ends of the slides that on mov-

ing the latter forward the tubing will bear against the sides of the vessel, and the water being withdrawn from the coffer-dam, the external pressure, acting on the packing strips, will cause the latter to close all apertures, and the stern will be exposed, so that the screw-propeller may be removed and replaced, or any desirable repairs made on the exposed portion of the stern.

To prevent leakage where the slides enter the end of the coffer-dam there is used a packing, the slides being kept in contact with it by set-screws.

The inventor states in addition that the coffer-dam should be built of such form as to displace the least possible amount of water, the tanks to be very large at top and small at the bottom, especially the after tanks, which are intended for balance tanks.

The tanks being large at top would allow a large amount of air space for working the dock, giving more perfect control and preventing accidents while the dock is being placed in position or removed.

There will be a pump placed on the after tank, connected with each and every tank; it can also be used as an auxiliary in removing water from the interior of the dam, the major part being pumped out by a large pump located on the tug towing the coffer-dam to the ship.

DREDGING MACHINERY.

The only exhibit of dredging machinery of any note is that made by the American Dredging Company of Philadelphia. The exhibit consists of several handsome models.

No new methods are shown, the models representing the dipper (or single scoop) and the grapple or clam shell dredging machines.

The improvements consist in the construction. Among the most important of these are: Using in place of wood, where possible, the Phœnixville riveted column; the new friction clutch or disk frictions patented by Mr. Weston; and improved grapples and buckets. These improvements will be found mentioned below.

HALL'S BUCKET FOR GRAPPLE-DREDGES.

This bucket is constructed of fewer parts than those used in other grapple-dredges. Advantages claimed are its simplicity, durability, and strength.

Furnished by American Dredging Company of Philadelphia.

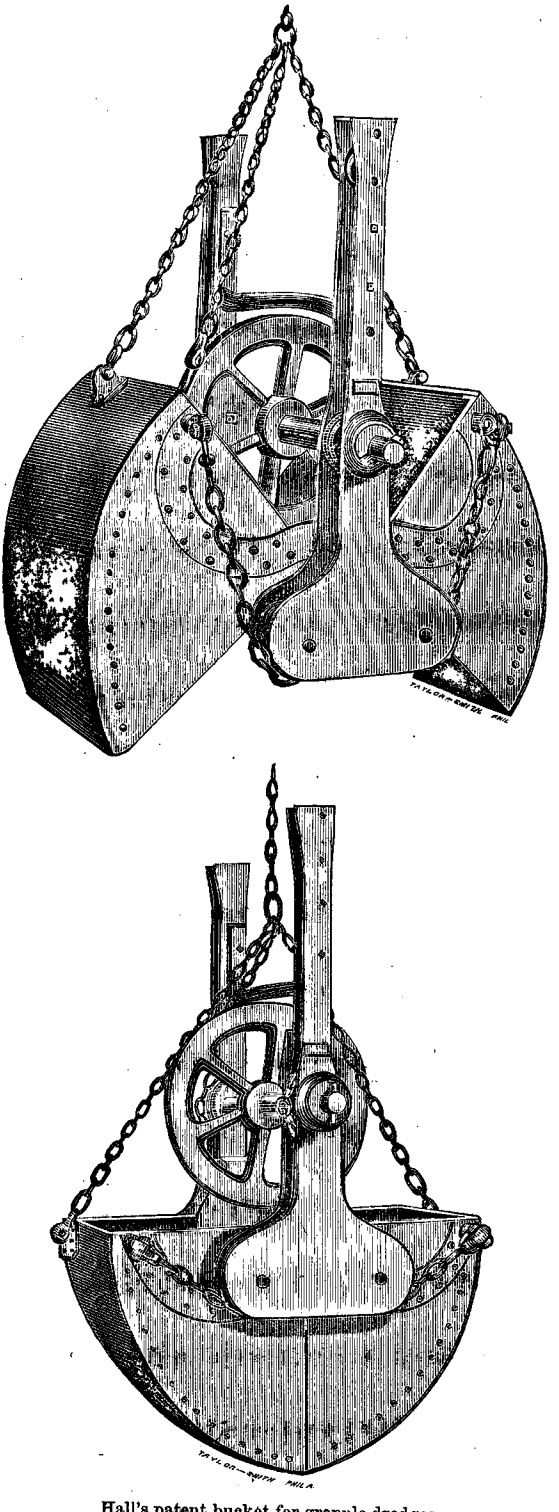
HOLROYDE'S PATENT GRAPPLE FOR DREDGES.

This grapple is designed for the removal of blasted rocks, bowlders, snags, cribwork, &c. The accompanying drawings need no explanation.

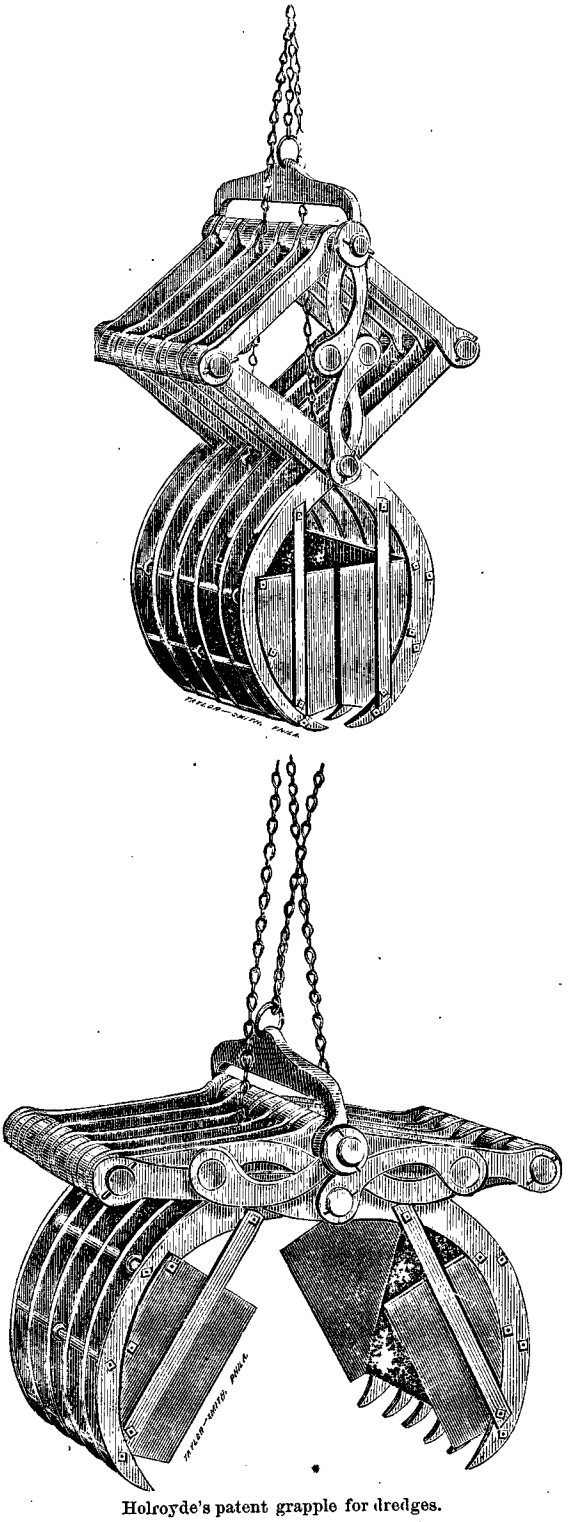
Furnished by the American Dredging Company of Philadelphia.

WESTON'S DISC FRICTIONS.

For description see "Weston's Pulley Blocks."



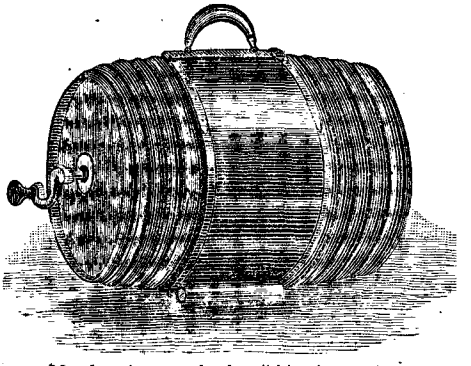
Hall's patent bucket for grapple-dredges.



Holroyde's patent grapple for dredges.

ELECTRICAL APPARATUS.

MOWBRAY'S "POWDER-KEG" BLASTING BATTERY.



Mowbray's "powder-keg" blasting battery.

The advantages claimed for this machine are as follows:

(1.) The exciting surface is a cylinder, in lieu of a plate, because, according to Hearder, in Philadelphia Magazine, Vol. XV, page 290, "Cylinder machines have a superiority above plate machines of equal surface, in the proportion of 4 to 1."

(2.) The rubber is so constructed as to avoid fouling the exciting surface with amalgam.

(3.) Should the operator, under nervous excitement of firing, reverse the crank violently, no damage ensues.

(4.) Larger condensing surface, thus avoiding perforation of the condenser.

(5.) Provision is made to absorb any moisture that may get within the case, so that time does not impair its efficiency when laid aside for months. The case is protected externally by an elastic rubber envelope.

(6.) There are no projecting knobs.

(7.) It only weighs twenty pounds.

(8.) In reversing, when 30° of a circle have been attained, the collecting points and rubber are separated from the condenser which is thereby insulated; now, a further reverse motion of like extent connects the condenser to the discharge sockets—a device possessed by no other battery hitherto constructed.

(9.) By using the above battery with Mowbray's exploders, fully 20 per cent. of the explosive may be economized. Two causes tend to this result: (1) Simultaneous discharge of several drilled holes, each helping the other. (2) These exploders, by their initial explosion, fully develop the extreme disruptive power of the explosive, whether mica-blasting powder, gunpowder, nitro-glycerine or any of the so-termed higher explosives.

This battery will, under every condition of the atmosphere, whether damp, dense, or rarefied, evolve, at the will of the operator, abundance of electricity, sufficient to fire fifty exploders charged with a perfectly safe and not "too sensitive" priming.

MOWBRAY'S MICA POWDER.

The superiority claimed for this mica powder arises from the following causes:

The tri-nitro-glycerine used is chemically pure, and owing to its being superficially laid on the mica scales (and not absorbed), its explosion is instantaneous throughout. No other compound offered gives a similar instantaneous explosion, for if an absorbent be used to take up the liquid nitro-glycerine, the portion which is superficial explodes first, and another portion, which is absorbed into the pores, explodes afterwards, and these two forces, one following the other, are not equivalent to one instantaneous explosion of the same force for blasting purposes. Similarly, when nitro-glycerine is mixed with nitrate sulphur, resin, charcoal, &c., these latter need time for their decomposition; thus there are two explosions, first, an instantaneous explosion of the nitro-glycerine itself, and second, of the nitrates, &c., supplementing the former. Now, an explosion of two weaker forces, one succeeding the other, is not equivalent to one instantaneous force greater than either of the two separate forces, when used for blasting purposes. It is true the ear cannot detect the two explosions, but the great difference of explosive force of nitro-glycerine when used naked in a drilled hole, as compared with a like quantity mixed with an absorbent, and then inserted in a drilled hole, can be satisfactorily explained in no other way.

ENGINES.

THE BALANCE ENGINE.

(Made by Wells Balance Engine Company, New York.)

This engine has two pistons in its single cylinder. From the front piston and through boxes near the edges of the cylinder-cover extend two piston-rods, each connected to a crank on the driver shaft. From the rear piston a single main piston-rod passes directly through the front piston, then through the middle of the cylinder-cover, and connects to a crank formed by making the inner sides of the two cranks already mentioned twice as long as the outer sides. That is, imagine a W with the middle angle twice as high as the side strokes, and consider a crank at each angle. The main piston-rod would then be attached to the angle at the apex, and the two smaller rods to the angles at the base. The cranks, it will be observed, are set in the same plane, and not quartering, as is usually the case. The steam ports enter the

cylinder at the middle and at the ends, and the stroke of each piston equals, of course, half the length of the cylinder. The steam enters between them and forces them apart, and then enters at the ends and carries the pistons together; the result is that the power is applied to the shaft just as the two hands are to the handle of an auger, and the reciprocating parts are balanced, while the engine runs at high speed with little vibration.

FORGES.

THE EMPIRE FORGE.

(Manufactured by the Empire Portable Forge Company, Troy, N. Y.)

The manufacturers claim the following advantages for these forges:

(1.) The motion is imparted to the fan, through gearing and friction pulleys, from a lever, worked the same as on the old bellows—doing away with the fatiguing crank motion.

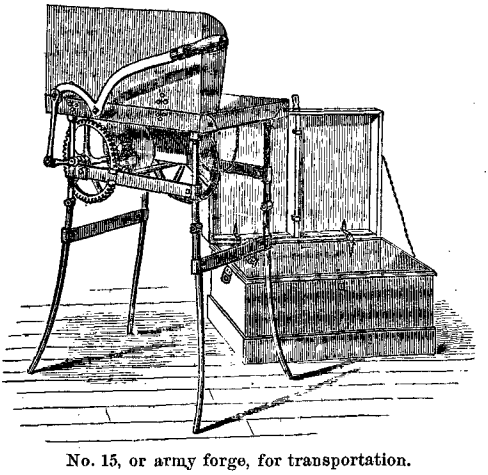
(2.) They are constructed entirely of metal, having no belts or bellows to wear out or stretch by damp weather, and are simple in their construction.

(3.) They give a continuous blast and no back draught.

(4.) They will heat a 3-inch bar to a welding heat in less than ten minutes, and will work iron from ½ to 8 inches as easily as a stationary forge.

(5.) They have the "bird's-nest" tuyere, allowing nothing to escape into the ash-box.

(6.) They are easily moved about from place to place, and are durable because all the shaft-journals run in bronze bearings, which can be replaced when worn at a very moderate cost, by sending for new ones



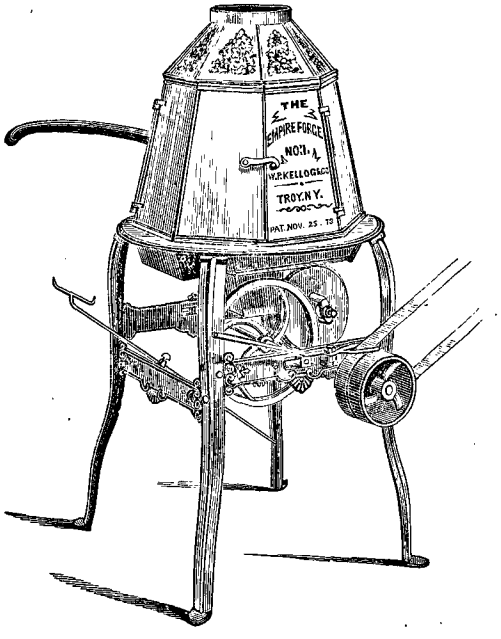
No. 15, or army forge, for transportation.

to the factory; and the fan is provided with oil-cups which will lubricate it for a long time.

This forge is made to fold up and pack away in a chest 2 feet 2 inches long, 1 foot 10 inches wide, and 1 foot 4 inches deep. Its weight is only 75 pounds.

The "army forge" is made of wrought iron, the legs and back folding together compactly when closed. This forge is designed for use on the mountains or plains, where they are transported for long distances, and where lightness and strength are desirable. It can be unpacked and ready for use in one minute.

Seven-inch fan; 18 by 16 fire-fan; 30 inches high, $50.



Geared for power. For shop use.

PRICE-LIST.

Both with and without hood and doors.

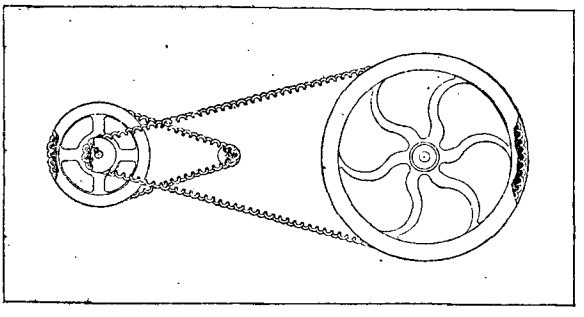
No.	Fan.	Diameter.	Height.	Weight.	Price.
	In.	*Ft. In.*	*Ft. In.*	*Pounds.*	
0, without hood	7	1 10	3 4	145	$35 00
1, without hood	7	2 1	3 6	155	40 00
2, without hood	8	2 3	3 9	250	50 00
3, without hood	8	2 7	4 0	285	60 00
0, with hood	7	1 10	3 10	175	40 00
1, with hood	7	2 1	4 0	185	45 00
2, with hood	8	2 3	4 3	290	55 00
3, with hood	8	2 7	4 6	300	65 00

KEYSTONE PORTABLE FORGES.

(Manufactured by Keystone Portable Forge Company, office 120 Exchange Place, Philadelphia.)

This company manufactures many different styles of forges. Only those will be mentioned which seem specially adapted to army use.

One of the recent additions to these forges is the chain gear, for



Chain gear.

which the company claims the following advantages:

(1.) Great durability.

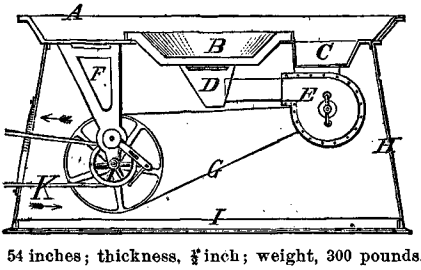
(2.) It can be used in all sorts of weather, is not liable to injury, and can be repaired by any blacksmith.

(3.) It has absolutely no slip.

(4.) It can be run quite slack, reducing friction and power without reducing blast as there is no lost motion.

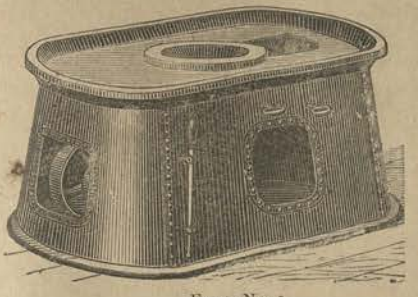
POWER FORGES.

Section.

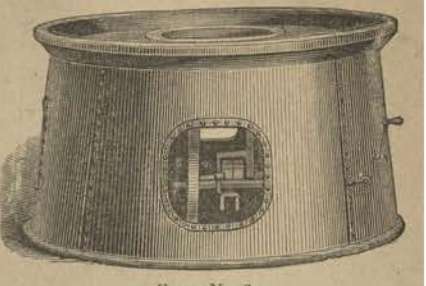


A. Fire-pan; diameter, 54 inches; thickness, ⅜ inch; weight, 300 pounds. B. Hearth. C. Water box for wet coal, &c. D. Tuyere-box, and ash receiver. E. Fan-blower, diameter 9 inches. F. Hanger, to which are attached 12-inch driving-wheel, and 4 inch fast and loose pulleys. G. Flat belt, 2½ inches wide, from 12-inch driving wheel to 2-inch fan pulley. H. Boiler-iron base with 4 manholes, each 12 inches square. I. Cast-iron sub-base. K. Flat driving-belt, 2 inches wide, which runs on 4-inch fast and loose pulleys.

One horse-power is ample to run eight of these forges.
The speed of the fan should be about 1,200 revolutions per minute.



Forge No 5.



Forge No. 6.

	Size of firepan.	Weig .	Price.
	Inches.	*Pounds.*	
Forge No 5 (oval fire-pan)	54 by 36	550	$145 00
Forge No. 6. (circular fire-pan)	54 by 54	600	160 00

RIVETING FORGE.

(Chain Gear.)

Riveting forge; price, $75.

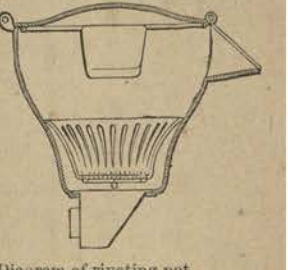


Diagram of riveting pot.

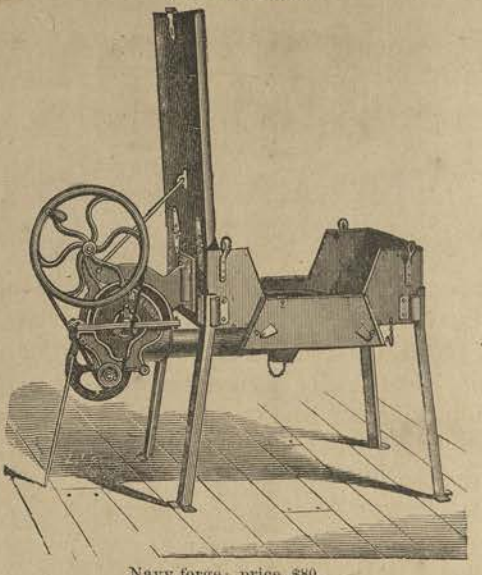
This forge has been constructed for the use of boiler-makers, ship-builders, &c., and will work with hard or soft coal or coke.

The frame is strong and firmly braced. The pot has three doors, the openings being closed, when not in use, by falling lids. The top of the pot is covered with a heavy lid, which is thrown open to kindle the fire, and closed when heating rivets, thus coking the coal and obtaining an intense heat.

The blast, entering the tuyere-box, passes through the tuyere grate and the sides of the basket, penetrating the fuel on all sides.

NAVY AND MINERS' FORGES.

(Chain Gear.)



Navy forge; price, $80.

Height, 22 inches. Size of fire-pan, 22 by 27 inches. Weight, 200 lbs. Diameter of fan, 9 inches.

The fire-pan is made of wrought iron, and is 10 inches deep, containing all the other parts of the forge when packed for transportation.

The blower and gearing are compactly framed together, and fit into a slot on the end of the forge when in use.

The legs, made of angle iron, fit into slots at the corners of the fire-pan.

The tuyere-box fits into a slot under the hearth.

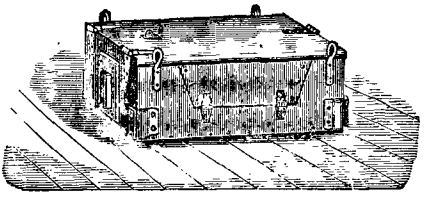
The hearth is made of heavy cast-iron, and is bolted to the bottom of the fire-pan.

The lid of the fire-pan is made of heavy sheet iron, and so attached by strong hinges that when the forge is in use it is raised perpendicularly, forming a back or fender.

This forge is designed for use on ships and steamers, and on land for army purposes, miners, wagon trains; wherever exposed to rough handling and use in transportation by land and sea. It can be set up for use or packed for transportation in one minute. Those made for ships and steamers have two eye-bolts on each side, by which they are secured to the deck-beams. Thus they are entirely out of the way when not in use, and are ready at five minutes' notice when required.

To pack the forge for transportation, the blower and gearing, legs and tuyere-box are withdrawn from the slots, and, with the short blast-pipe are placed in the fire pan. The falling doors, at the sides of the fire-pan, are closed and fastened. The lid is shut down and fastened by a hasp. The entire forge thus packed occupies a space only 22 by 27 inches square and 10 inches deep.

This forge will produce a quick welding-heat on iron of 2 inches diameter, and on larger iron if required, as there is plenty of spare blast.



Navy forge (packed).

MINERS' FORGE (CHAIN GEAR).

The forge is about 15 by 22 inches square and 6 inches deep, will weigh 70 pounds, will have a 6-inch fan, and general capacity same as blacksmith's forge No. 1. It is designed specially for prospecting miners, pack trains, cavalry use, engineering and surveying parties, &c., wherever a smaller, lighter, and cheaper forge than the navy forge is required.

The price of the miners' forge is $45.

HOISTING MACHINERY.

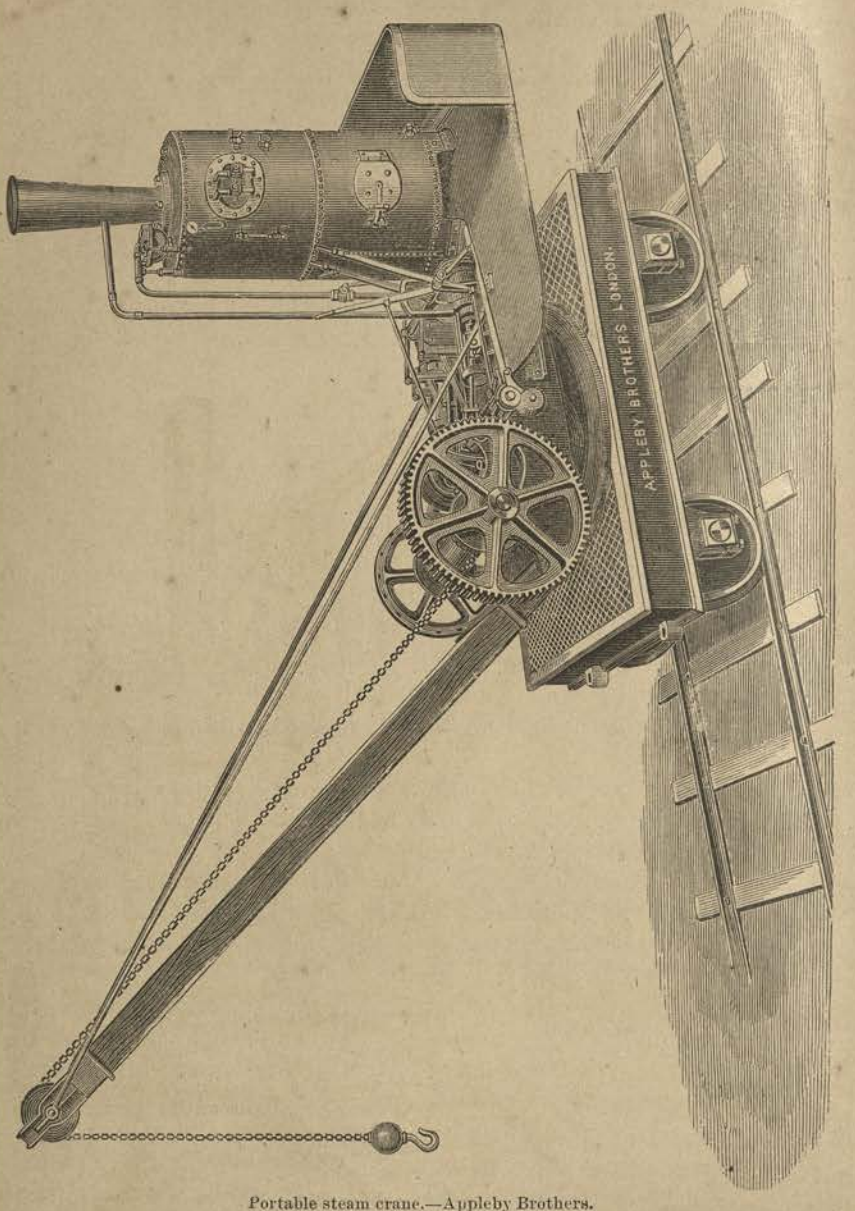
Messrs. Appleby Brothers, Emerson street, Southwark, London, S. E., exhibit several locomotive steam cranes, two of which were selected by the Centennial Commissioners for unloading and placing the heavy portion of the exhibits. These cranes can—

1. Lift and lower;
2. Turn completely round in either direction simultaneously with the lifting or lowering;
3. Alter the radius by raising or lowering the jib-head; and,
4. Travel along rails by steam; all of these motions being worked by one man who attends to the boiler.

The cranes made by this firm which would probably be most useful to engineers are: the portable steam crane with fixed jib, the improved single-cylinder contractors' portable steam crane or hoisting engine, and the single-cylinder hoisting engine.

The former is of a different type from those mentioned above, the object in designing it being to make a cheap and simple crane, capable of performing the two functions of lifting the load and turning entirely around, but not requiring a variable radius, or a steam traveling motion. This crane revolves on a strong central pin instead of the usual crane post; the gear and working parts are kept close to the center of gravity; and the cylinders have link reversing motions, and are placed horizontally so that the driver may have nothing to obstruct his view. The brakes and other levers and clutches are placed conveniently for ready handling, and the lifting and slewing motions may be worked simultaneously in either direction without stopping or reversing the

engine. The gauge of rails on which the crane travels is usually 4 feet 8½ inches, but it may be varied to suit. The jib can also be made to any reasonable radius, but it is usually about 14 feet from center of



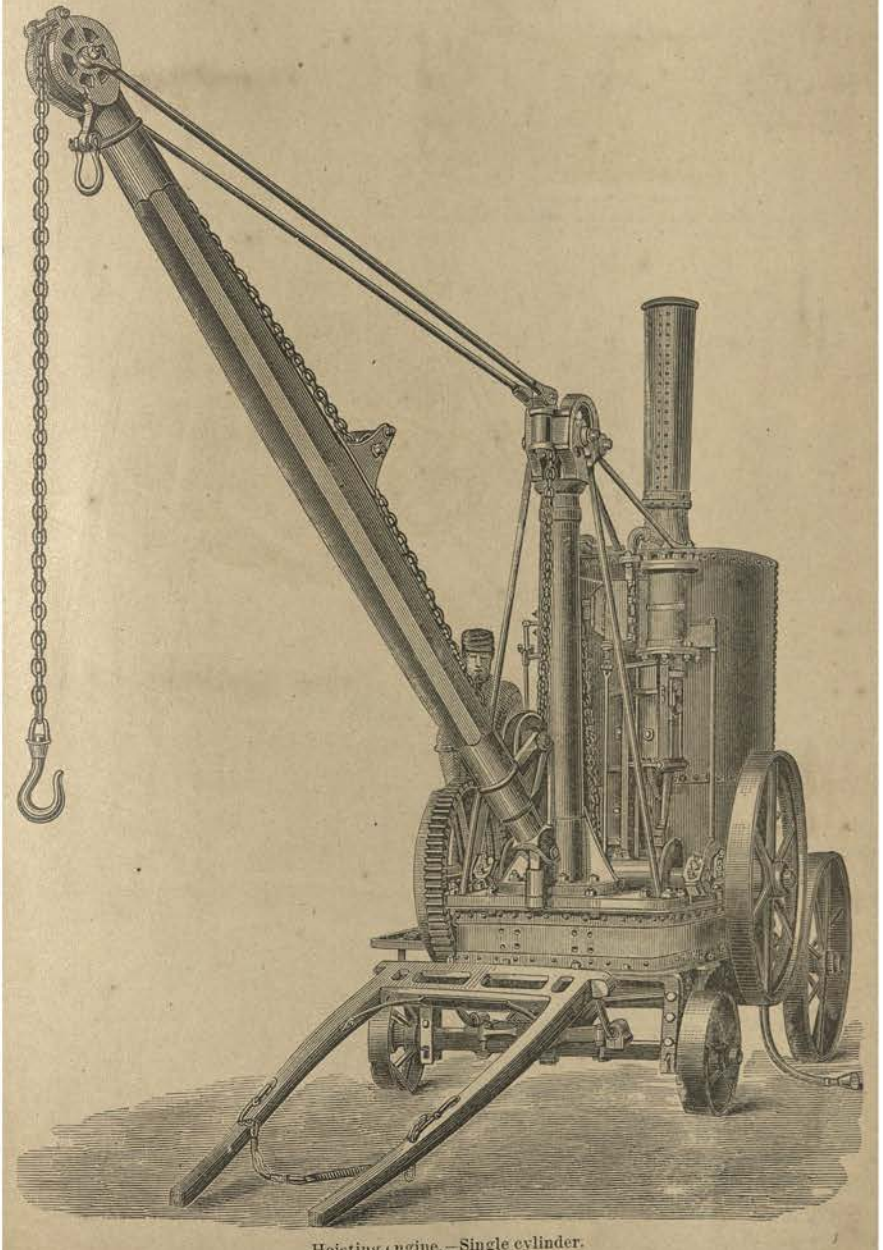
Portable steam crane.—Appleby Brothers.

crane to the plumb line of the chain. The engraving represents a crane to lift 5 tons, and has two cylinders; the smaller sizes have only one cylinder, but are in other respects similar.

Price list of portable steam cranes.

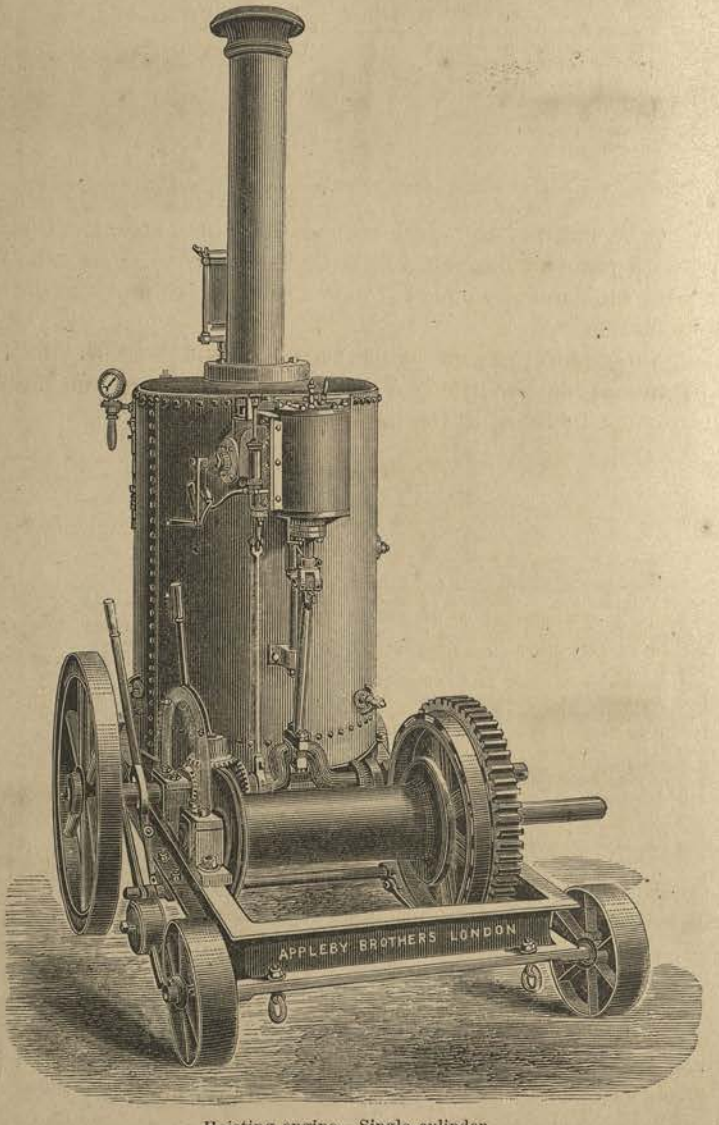
Power of crane in tons	1½	3	4	5
Maximum radius with full load, feet	12	14	14	14
Price of crane to lift and slew	£250	£300	£350	£430
Price extra, if with two cylinders	£15	£18	£20	.....
Approximate weight in tons	6	7	9	11
Approximate measurement, cubic feet	300	400	450	500

Packing for shipment and delivery, F. O. B., Liverpool, six per cent.



Hoisting engine.—Single cylinder.

The improved single-cylinder contractors' portable steam crane or hoisting engine is made with pillar and jib to swing fully half round, and chain to reach 15 feet below ground line; an 8 horse-power crane, the size generally used, will lift and deal with loads of 30 cwt. at quick speed and with single chain.



Hoisting engine.—Single cylinder.

CONTRACTORS' STEAM CRANES.

	Single cylinder.					Doulbe cylinder.		
Nominal horse-power	3	4	6	8	12	6	8	12
Diameter of cylinder ..... inches..	5½	6	7¼	9	11	5½	6	7¼
Price, with road-wheels, shafts, and locking-plate..	£190	£228	£260	£295	£370	£286	£355	£415
Price, with plain or flanged wheels for trams or railway (without shafts and locking-plate)...	185	223	255	289	360	281	350	405
Price, without wheels and axles for fixing on-timber, brick or other foundations.....	180	218	249	282	352	275	343	397
Extra for governors and expansion-valve.....	10	12	13	30	25	15	20	25
Extra for link-motion reversing gear	7	8	10	11	12	15	18	20
Extra for felting, lagging, and covering boiler with sheet-iron.....	10	12	13	15	16	13	15	17
Extra for skeleton roof	8	9	10	10	10	10	10	10
Extra for packing for shipment	7	8	9	10	12	9	10	12
Approximate weight ..... tons..	3½	4½	5	7¼	8½	4	7	8½

The single cylinder hoisting engine for lifting barrows or building materials, &c.

The boiler, engine, and gear are mounted on a strong wrought-iron frame, with plain or flanged wheels. The boiler has an ash-pit, with feed-water tank under, so that it may stand on a timber staging or floor without danger.

The 3 horse-power engine will lift loads of 15 cwt. with single chain. A capstan end may be fitted on the long end of the barrel shaft. The capstan is not included in the list of prices.

HOISTING ENGINES.

	Single cylinder.					Double cylinder.		
Nominal horse-power	3	4	6	8	12	6	8	12
Diameter of cylinder..... inches..	5½	6½	7½	9	11	5½	6½	7½
Price, with plain or flanged wheels for tram or rails (without shafts and locking-plate).....	£155	£195	£220	£245	£315	£250	£288	£360
Price, without wheels and axles (for fixing on brick or timber).....	150	190	214	238	307	244	281	252
Price, with road-wheels, shafts, and locking-plate..	160	202	228	255	325	255	295	370
Extra for governors and expansion-valve.....	10	12	13	20	25	15	20	25
Extra for link-motion reversing gear	7	8	10	11	12	15	18	20
Extra for felting, lagging, and covering boiler with sheet-iron	10	12	13	15	16	13	15	17
Extra for skeleton roof	8	9	10	10	10	10	10	10
Extra for packing for shipment.....	6	7	8	9	10	8	9	10
Approximate weight..... tons..	2¾	3½	3¾	5¾	7¼	3¾	6	7¾

Packing for shipment and delivery, F. O. B., Liverpool, 6 per cent.

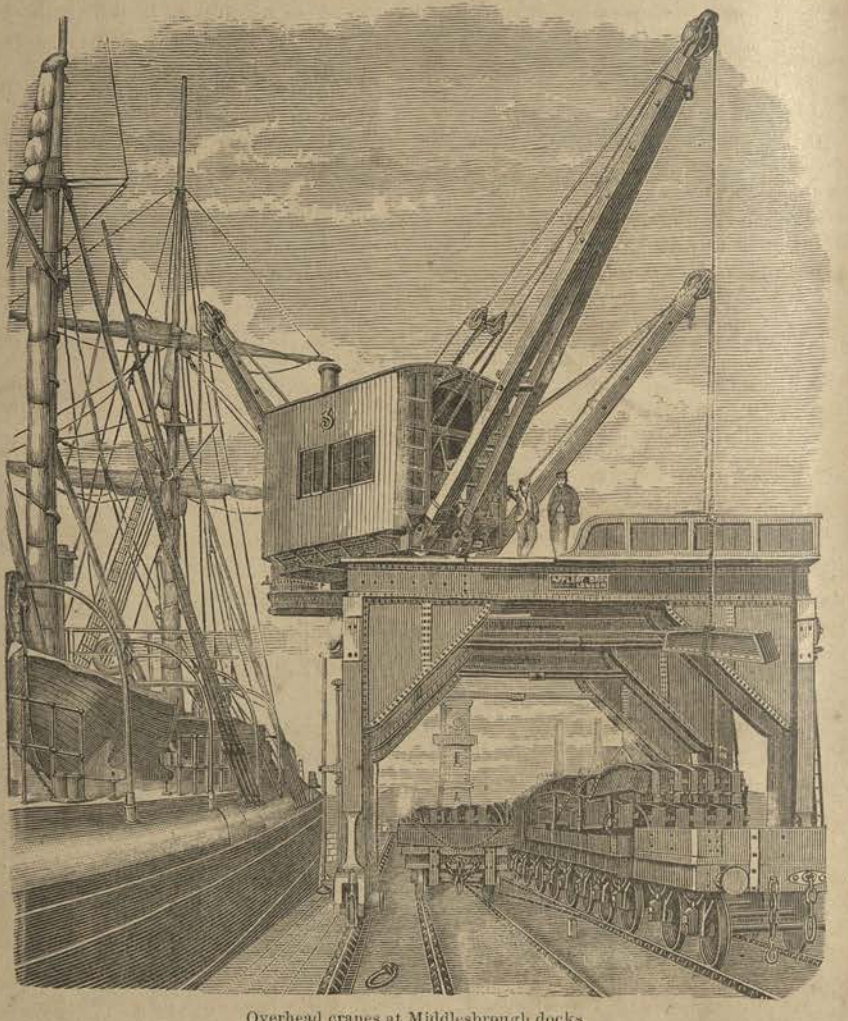
Appleby Bros. also make hand-cranes, concrete-mixers, mortar-mills, portable dredgers for mud and sand, &c., for a description of which the reader is referred to their illustrated catalogue.

OVERHEAD STEAM CRANES AT MIDDLESBROUGH DOCKS.

These being especially large appliances of this nature are deemed worthy of notice. The description is taken from "Engineering":

The traveling frame, or gantry, of each crane has a span of 23 feet center to center of rails, one of the latter being laid close to the edge of the quay, and the other in the 6 feet between rails. The clear height is 17 feet 6 inches, which allows the uninterrupted circulation of locomotives and all kinds of rolling stock on each of the two lines of rails which are spanned by the gantry. The traveling wheels are 12 feet cen-

ter to center. The framing is composed of a pair of timber uprights, braced and strengthened by cast-iron brackets and two wrought-iron plate girders, which are connected to the timber uprights by four wrought-iron plate brackets, strengthened with angle irons. A strong carriage, with the necessary roller path and brackets for the gear required to transmit the traveling motion, which will shortly be referred to, is firmly bolted at the extreme end of the girders nearest to the dock, while the girders are planked over so as to form a store for coal and water. The crane and the whole of the substructure is designed for a working load of 5 tons at the maximum radius of 21 feet from center of crane-post to the plumb-line of the lifting chain, while



Overhead cranes at Middlesbrough docks.

the crane itself is of precisely the same construction as those which have given satisfactory working results elsewhere, with apparatus for altering the radius by steam from a maximum of 24 feet to a minimum of 14 feet.

The traveling motion is transmitted from the crane-engines by suitable gear and shafts to the traveling wheels, and warping drums or capstans are fitted on a countershaft on the inner side of each frame, so that these warping drums can be driven in-

dependently of the traveling wheels, and they are used for moving the trucks into position below the crane, as they are required for loading and unloading. This simple addition is found to effect a very large saving in manual labor and time, which, it is estimated, amounts to at least £300 per year, because, without this appliance, horses and locomotives must be kept constantly employed, involving working expenses and wear and tear, in addition to the maintenance of the road, whilst with the capstans the trucks are brought into position by the men in stowing and slinging, with no further wear and tear of road than that due to the paying load. As it was decided to adopt this system of crane throughout the dock, the two lines of rails spanned by the gantry are laid with crossings at such intervals as will admit of either line being used for full or empty trucks, or in fact partially for both purposes if desired.

Another great advantage which has been demonstrated by practice is, that the cranes can be so readily concentrated at any point where they may be required; and, indeed, as is shown in the engraving, three of these cranes are brought to load a long screw steamer having three hatchways. This is evidently a most important consideration with owners and shippers, especially under circumstances which so frequently arise where great dispatch is essential. Or two cranes can be brought together for any exceptionally heavy lift. The cranes were tested with the maximum working load of 5 tons, and subsequently for speed, when each crane delivered 50 tons per hour from the trucks into the steamer's hatchwa

ROAD LOCOMOTIVE CRANE ENGINE.

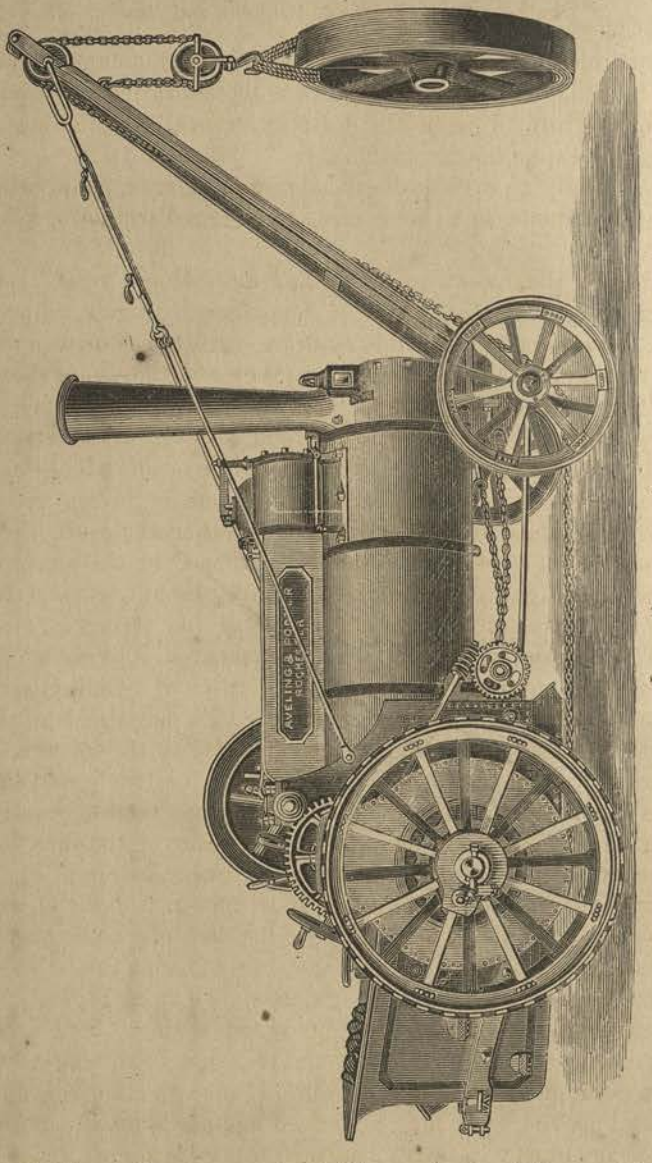
Made by Aveling & Porter. William Churchill Oastler, sole agent for the United States, 43 Exchange Place, New York.

This engine can be moved from place to place by its own power and draw very heavy loads, a 6 horse-power engine, on trial at South Orange, N. J., in 1872, pulling a train of ten wagons, the total load being 63,400 pounds, up a hill with a rise of 4.27 feet in 100, a length of 1,435 feet. Each of these wagons could be drawn up the hill by two good horses, but with great effort, so this engine performed the work of twenty horses. It might be found useful for military purposes and for contractors' work in general.

A short description of some of its peculiarities may be of interest.

The *single cylinder* is placed on the forward part of the boiler, and is surrounded by a steam jacket in direct communication with it. The steam is taken into the cylinder from a dome connected with a jacket. Priming is by this means prevented; the use of steam pipes either inside or outside the boiler is rendered needless, and a considerable economy in fuel is effected. The crank-shaft brackets are formed out of the side plates of the fire-box, extended upward and backward in one piece, so as not only to carry the crank-shaft, but to provide bearings also for the counter-shaft and driving axle, in the most convenient position. This patent arrangement produces a combination of much strength and lightness, reduces to a minimum the loss and annoyance from leakage or strained bolt-holes, and unites all parts peculiarly exposed to injury by jarring, with such firmness as to give almost absolute security against such injury on even very rough roads. The driving-wheels

are of wrought iron, and are fitted with compensating motion for turning sharp curves without disconnecting either wheel, both being at the same time kept in gear, and taking their fair proportion of the load



Locomotive crane engine.

without slipping; they carry about 85 per cent. of the weight of the engine. The engine is steered from the foot-plate, so that the entire management of driving, steering, and working the crane is performed by one person. The engraving represents an engine fitted with a crane to lift up to 2 tons.

THE "GROOSOKAT," OR PORTABLE TRAVELING CRANE.

Invented by Mr. N. Wonlarlarsky, St. Petersburg, Russia, and patented in the United States, Austria, England, Belgium, and Russia.

This machine is designed to form a convenient means of transshipment of materials where the distance is too short for a railroad track or too long for unloading by the ordinary cranes. It combines the two elements of cheapness and portability.

It is essentially a portable overhead traveling crane, supported at intervals upon tripods, or in some cases two-legged supports, as shown in the figures.

Fig. 1 shows the apparatus as used in unloading a vessel, conveying the merchandise to a distance, and depositing it upon a railway truck. Fig. 2 is a side view of the tramway beam, with the suspension eyes and truck. Fig. 3 is a short section in two views of the same, showing the construction of truck and beam. Fig. 4 shows a cheaper form of beam and truck, with the former made of wood, as well as the wheels of the latter. Fig. 5 shows the splice for joining two or more lengths of beam

As shown, the beam is built up of plate and angle iron, riveted, and consists of two separate stringers, held together at proper intervals by appropriate cross-webs. At intervals, governed by the strength of the beam and the intended maximum load, are placed pieces in form of a staple of plate iron, riveted to the inside of the stringers, and to the crown of which the suspension eyes are secured. As shown in Fig. 3, the beam is encompassed by a yoke, the crown of which passes below it, and on the inside of the upper ends of which the wheels of the truck are pivoted, the suspension-rods passing between the wheels. In this way there is free passage from end to end for the truck, and the whole may be supported at as many points as may be found necessary.

In Fig. 2, is shown a stationary staple for securing the ends downward when used with but one support, as seen in the background, Fig. 1. The beams are made in sections of about 28 feet long, as many of which may be jointed together as is necessary for the distance to be traveled, the splice being made by placing the piece (Fig. 5) inside the beam with four square-bodied bolts passing through, as shown at A, Fig. 2.

This apparatus is designed to convey loads up to about 18 cwt. In existing machinery for the hoisting and transporting of materials—aside from the permanent overhead traveling crane—the horizontal distance through which the load may be moved is quite limited, confining this species of machinery to heavy loads, if profitably done; and with such the apparatus in question does not compete for public favor, except where such is used for comparatively light loads. The ordinary swinging crane is vastly more expensive, and very much less efficacious, where loads of a ton or less are to be moved, while this portable crane is far

FIG. 1.

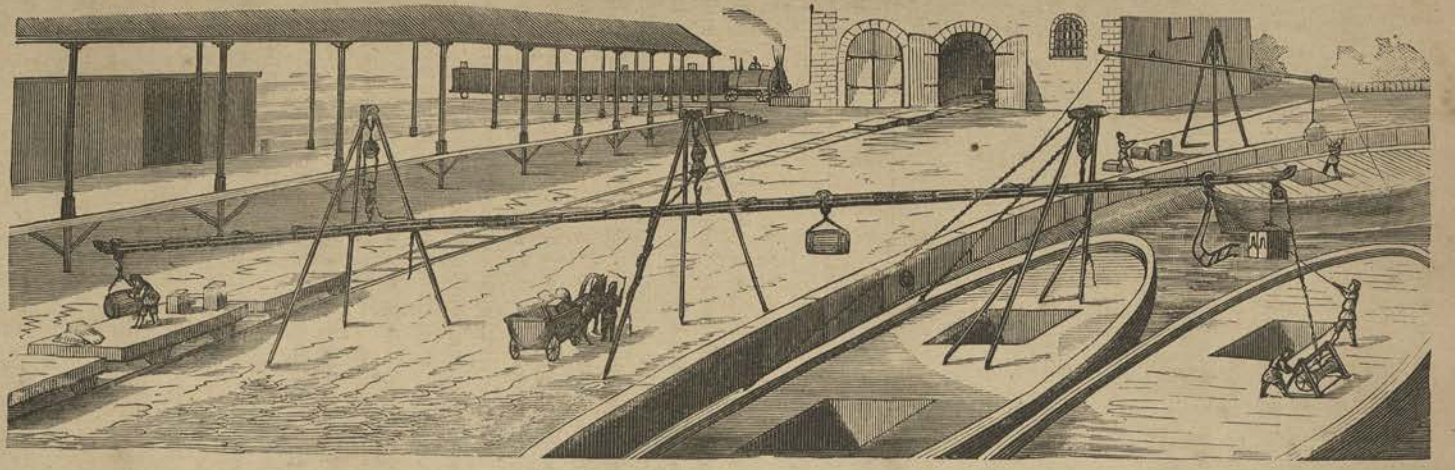
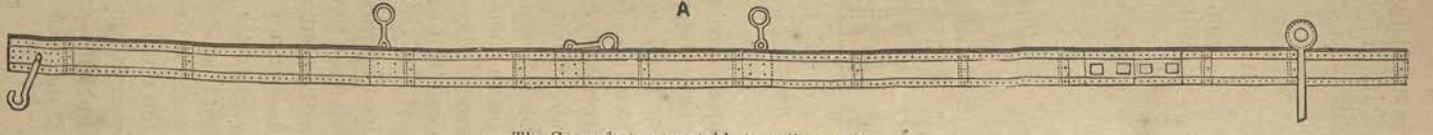


FIG. 2.



The Groosokat, or portable traveling crane.

superior in the distance through which loads may be conveyed, is cheaper, and above all quite portable. For the discharge of goods of uniform shape, such as bags, casks, cases, and bales, or of such materials as coal, sand, stone, &c., which readily conform to some uniform kind of receptacle, it is very well adapted, as the chair, as shown on the right (Fig. 1), the chime hooks, as seen in the center, or any convenient form of support for the particular load, may be attached to the truck yoke.

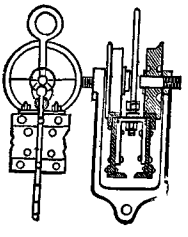


FIG. 3.

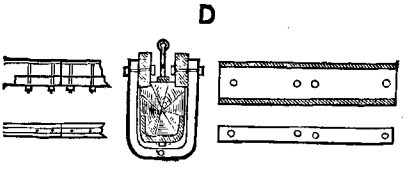


FIG. 4.

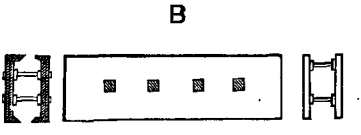


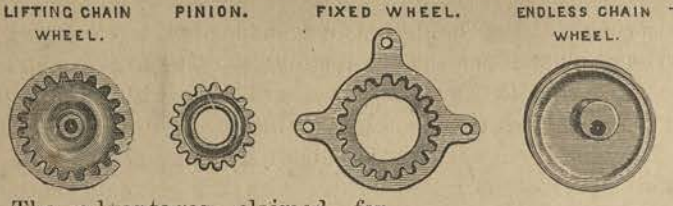
FIG. 5.

The tripods are generally about 20 feet high, but can, of course, be made to suit the particular work for or locality in which it is to be used. The beam is suspended from these by means of a block and fall, in order to adjust the beam to the inclination necessary to convey the load from end to end, which in this machine is done by the action of gravitation. This feature in it will limit its length, as, if constructed for too great distance, the required elevation of the goods at the higher end will be an inconvenient amount. The work of horizontal transport in this case is, of course, done in the hoisting of the load to the high end of the beam; but it is doubtless economically performed in that way, as generally the same manual labor which is required to raise the load to the required height suffices to guide it to the lower end, or place of deposit, returning the empty truck and sling by the same means.

This instrument is advantageously used for distances up to 100 feet. For the suspension of the beams from the tripods, the Weston differential block is preferably used, as it gives a convenient means of adjusting the heights and of securing it when adjusted. A very convenient way of using it for unloading vessels is to connect the support for the load to the truck-yoke with a self-checking block and fall, or a differential block of the single-sheave kind, and use the same fall for a guy to regulate the descent, and for lowering away at the discharging end of the crane. In this way light loads may be transshipped very rapidly.

PICKERING'S PULLEY-BLOCK.

Manufactured by Charles Merrill & Sons, 556 Grand Street, New York.

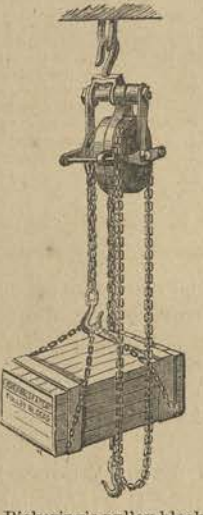


The advantages claimed for these blocks are that they are simple, strong, and powerful; they sustain the load and cannot slip; the hand chain being independent of the lifting chain, it does not accumulate under the foot as the weight is raised. The chain does not *kink* or *jam* in the upper block. Very easy to work, and not liable to get out of order.

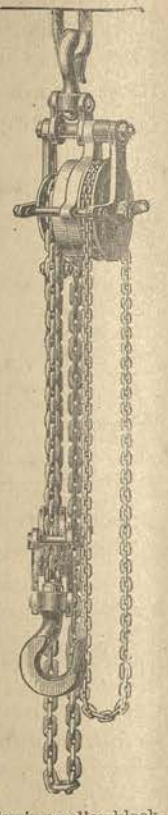
The lifting-chain being supplied with a hook at each end, no lowering is required for a fresh load.

Longer or shorter chains can be changed by simply unscrewing the nuts.

The working parts run on steel, and, being internal, are not liable to accident, and are free from dust or dirt.



Pickering's pulley-block to hoist 3 tons.



Pickering pulley-block of 3 tons and upwards.

Having two chains independent of each other, they work with less friction and more speed than most pulley-blocks. They can be worked at any angle, thereby enabling the workman to stand from under the load.

PRICES.

To raise—	Weight of block.	Lift.	Price.	Extra lift, per foot.
	Pounds.	*Feet.*		
½ ton	24	8	$22 50	$1 00
¾ ton	35	8	25 00	1 20
1 ton	65	8	30 00	1 50
1½ tons	95	8	40 00	1 75
2 tons	110	9	50 00	2 00
3 tons	120	10	75 00	2 20
4 tons	140	10	95 00	2 40
6 tons	.....	12	150 00	3 75
10 tons	.....	12	300 00	6 00

WESTON'S DIFFERENTIAL PULLEY-BLOCKS.

Made by Yale Lock Manufacturing Company, Stamford, Conn.

Advantages claimed.—They hold the load suspended at any point. They never "run down" under any circumstances. One man can hoist 1,000 pounds with ease with the small sizes, and more with the larger ones. Lifting and lowering are effected by pulling opposite sides of the slack chain. The chain will not twist or mount the sheaves. One man with this tackle is better than four or five with the ordinary double block.

PRICE LIST.

Plain blocks.	Price.	With sprocket wheel.	Price.	Geared.	Price.
½ ton, complete	$22 50	1 ton, complete		1 ton, complete	$50
½ ton, complete	25 00	2 tons, complete	$75	2 tons, complete	80
1 ton, complete	30 00	3 tons, complete	100	3 tons, complete	120
1½ tons, complete	40 00	4 tons, complete	140	4 tons, complete	170
2 tons, complete	50 00	5 tons, complete	200	5 tons, complete	225
3 tons, complete	70 00	6 tons, complete	300	6 tons, complete	300
		8 tons, complete	400	8 tons, complete	
		10 tons, complete	500	10 tons, complete	

Hoists are made to work by hand, horse, or steam power.

The following descriptions were kindly furnished by Mr. Weston:

Weston's patented improvements are primarily applicable to the various forms of hand-worked hoists, including the simple "wheel and axle," the "winch or crab" having its winding drum driven by toothed gearing and crank handles, or by endless hand-ropes, derrick or jib cranes, traveling cranes, and, generally, to all hoists constructed for hauling in and paying out a rope or chain. The new features are—

1st. A "*disk*" *friction brake* and clutch, compact in form, but possessing friction surfaces of large area.

2d. *Circular inclines*, or screw faces, operated by a hand wheel, for controlling the brake, and by which also the brake action is made automatic.

3d. *Ratchet connections* between the shafts and gearing, by which the speed and power can be changed instantly while hoisting.

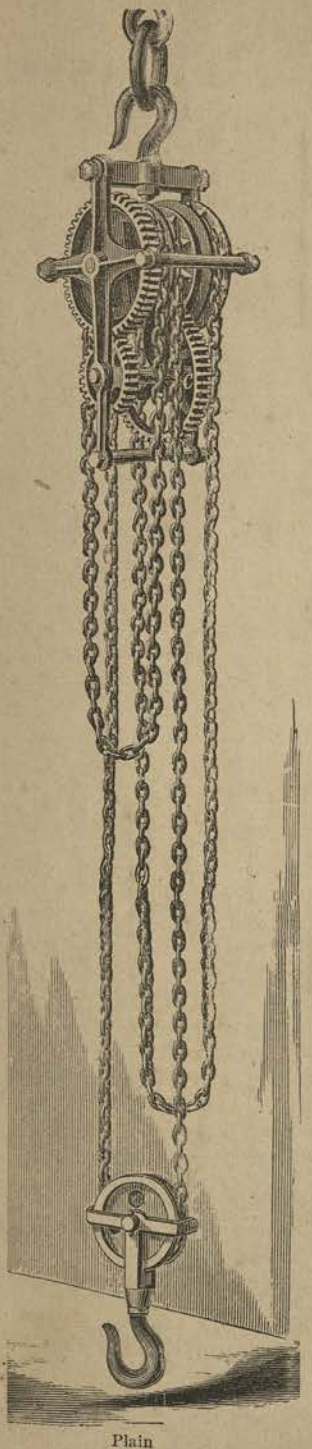
4th. *Traversing and traveling motions* in traveling cranes, obtained by wire cables or chains, and operated from one point, without the use of gearing and heavy cross-shafts.

The *disk brake* is placed within the wheel or drum, for which a frictional connection is required. The other novel features are equally compact.

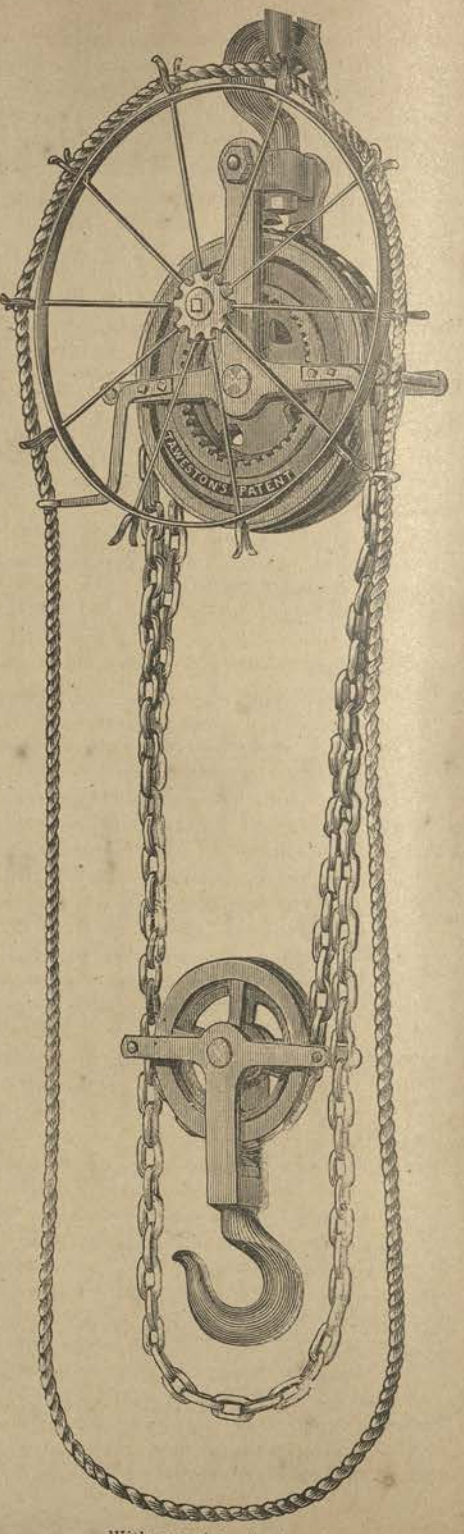
Among the practical advantages are the following: In crank-handled winch or crab the operator can lower the load by simply pushing the handle backwards continuously. The handle cannot recoil upon him, the load remaining at rest the instant the handle is released. Such a winch affords absolute security in varying the angle of a crane-jib, setting it inwards or outwards when loaded without risk, and giving the utmost dispatch in handling loads.

In another arrangement of a crank-handled winch a slight backward motion of the handle releases the drum wholly, so that the unloaded chain can run off at once. Should a load be suspended, its descent can be controlled or arrested at pleasure, by pushing the handle forward slightly in the direction for hoisting.

The crank-handles alone give complete control of the hoist at all times, with perfect safety to the operator. The last-named arrangement is well suited for hand-worked pile-drivers, as the operators can run off the chains and drop the "follower" the instant a blow is struck without losing hold of the cranks by simply "backing" them a few inches.



Plain



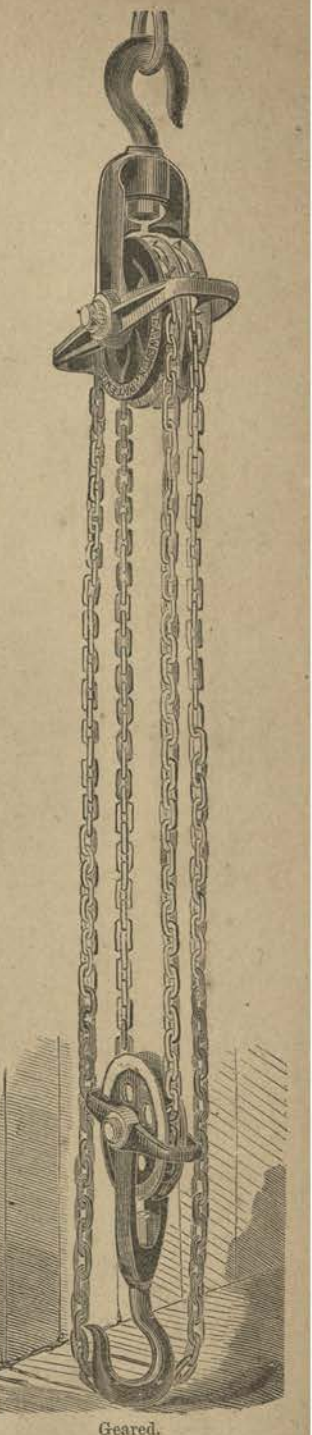
With sprocket wheel.

Both arrangements of a handled winch present the same external appearance. The construction of each is shown in section, Figs. 1, 2, and 3 (page 530). In these examples the disks and winches are shown as applied to the pinion and rachet wheel of the winch. This involves less cost than to apply them directly to the winding drum; the latter being the preferable plan, and the one always adopted for large hoists, as it permits the gearing to be at rest in lowering the load.

Figs. 4 and 5 (page 531) show a wheel and axle hoist with the brake in the drum, the inclines being replaced by an ordinary screw thread upon the shaft; the whole arranged for rapid lowering, under control of the endless hoisting rope.

In double or treble geared winches the change of speeds is effected by reversing the rotary motion of the cranks; a separate hand wheel or crank being provided for the self-arrested safety lowering motion. The ratchet connections for thus changing speeds are contained within the pinions, and are as strong and durable as the shafts carrying them. In a "three-speed" overhead hoist, to be operated from below, two endless hand chains afford the choice of either one of the three speeds in hoisting, with the self-arrested safety motion for lowering direct from the barrel, without disturbing the gearing and shafts. The first of these endless hand chains gives a treble purchase if pulled upon one side, and upon the other side a single purchase; the second gives a direct hoisting motion on one side, for coiling up the slack chain rapidly or hoisting a light load; and on its other side it gives the self-arrested safety lowering motion, or serves to run off the unloaded chain rapidly from the barrel when required. The motions are each capable of instant use without the intervention of the clutches or levers encumbering ordinary hoists, the use of which always involves loss of time, danger, and sometimes accidents.

The traveling crane, Fig. 6 (page 532), when arranged to be worked from below, has all its horizontal motions controlled by two endless hand chains or ropes hung from two sprocket wheels upon the crab or truck *E*, in the sketch, which is a plan or bird's-eye view; *G G*^{1} are the rails or tracks, spanned by a girder or bridge, *F*, which has the usual trolley wheels at its ends *F*^{1} *F*^{2}. The truck *E* has the usual traveling wheels for traversing upon the bridge *F*, and it may suspend a differential pulley for hoisting the load, or carry a general hoist and winding drum of any desired capacity. Upon pivots fixed to the truck *E*, are carried the sprocket wheels *A B* and *C D*. Each one has cast upon it a small chain wheel, to gear with and grasp the chain cables, *A B* acting upon the chain *I*, and *C D* upon *H*. The cables are strained at their extremities by weights or springs to keep them "taut." Guiding sheaves are fixed to the bridge, where the cables turn at an angle,



Geared.

and also on each side of the chain wheels to hold the cable in gear with them, but the latter are omitted from sketch. The four pendent sides of the two hand chains

Fig. 1. *Hoisting Crab, lowered by handle continuously, for slow lowering.*

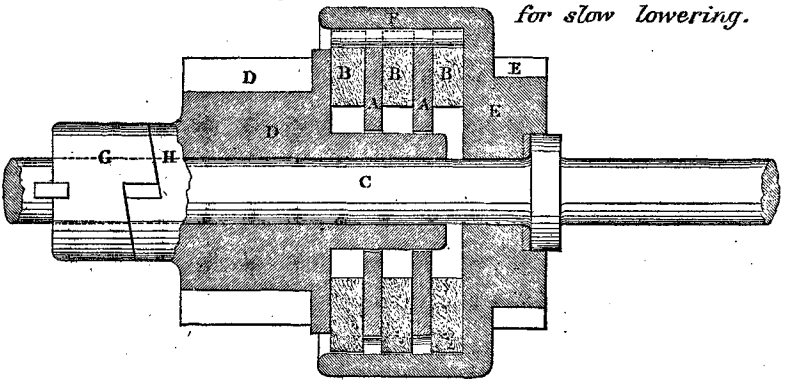


Fig. 2. *Hoisting Crab, stopped by handle in lowering, for quick lowering.*

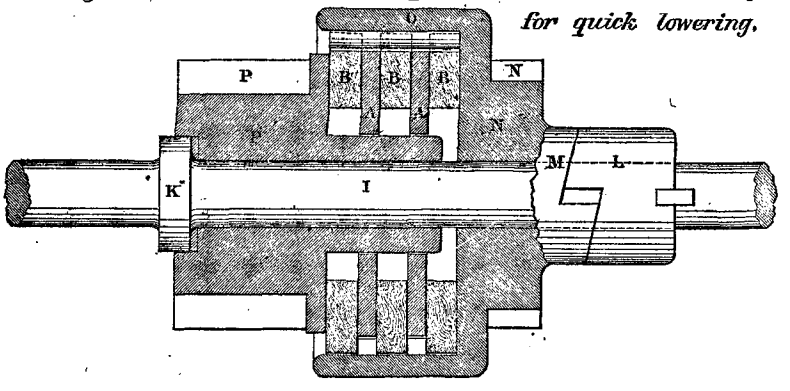
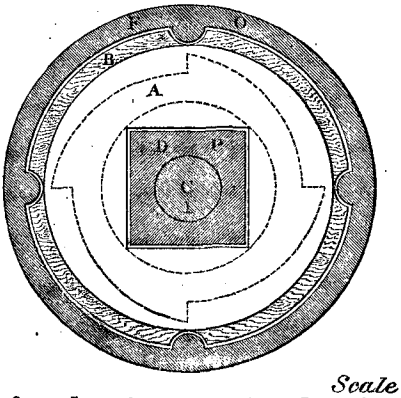
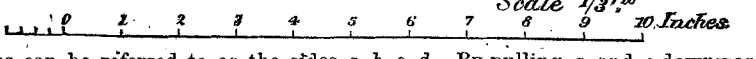


Fig. 3. *Transverse Section of both Crabs.*





or ropes can be referred to as the sides *a*, *b*, *c*, *d*. By pulling *a* and *c* downwards together, the truck *E* is propelled thus ⟶ along the bridge. By pulling *b* and *d*

together; the truck moves backward thus ← on the bridge. In both cases the chain wheels rotate together in the same direction, traversing over the parallel cables, crossing the bridge, and taking the truck with them. By pulling *a* and *b* together

Sack Hoist,
stopped by rope in lowering,
for quick lowering.

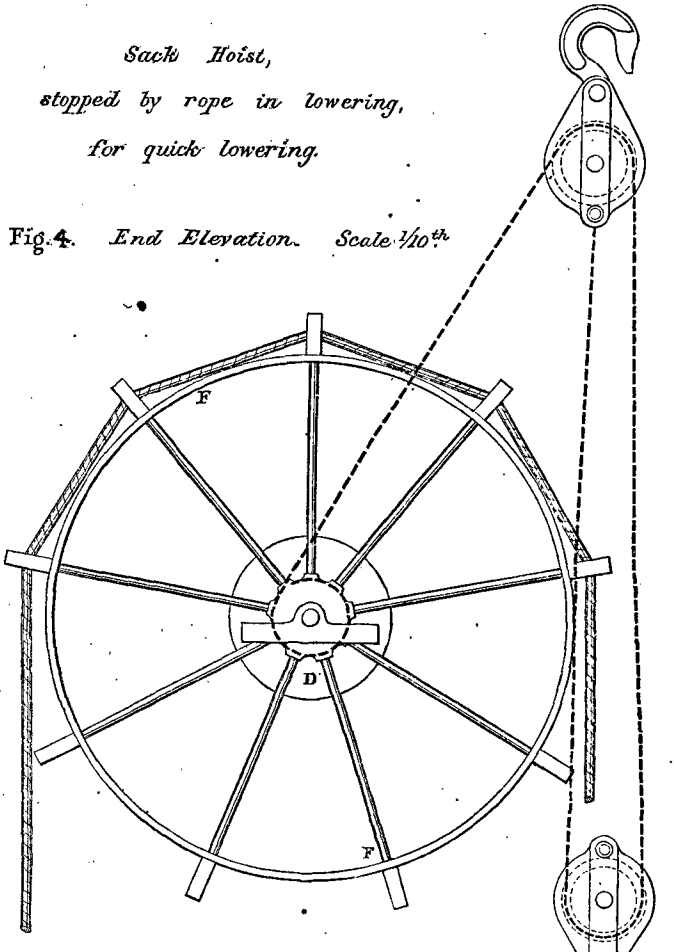
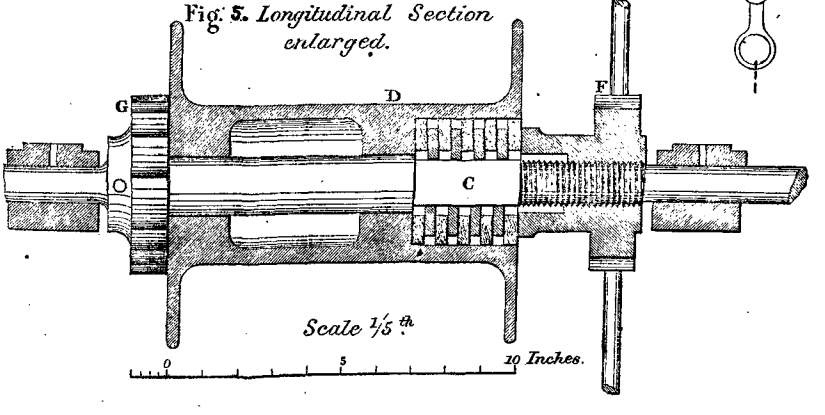


Fig. 4. *End Elevation. Scale 1/10th*

Fig. 5. *Longitudinal Section enlarged.*



the truck remains at rest on the bridge, but the bridge is propelled ↑ towards the north end of railway. By pulling *b* and *c* the bridge is moved towards ↓ the south end. In the two last-named cases the sprocket and chain wheels are rotated in contrary directions. Diagonal motions are obtained by pulling *a*, *b*, and *c* and *d* singly. Thus *a* gives motion in this direction ↗, *b* ↙, *c* ↘, *d* ↖. These diagonal motions are of course due to the combined movement of the truck crosswise of the bridge, and of the bridge lengthwise of the railway. The movement of the truck upon the bridge is due to the direct pull on the one cable so acted on.

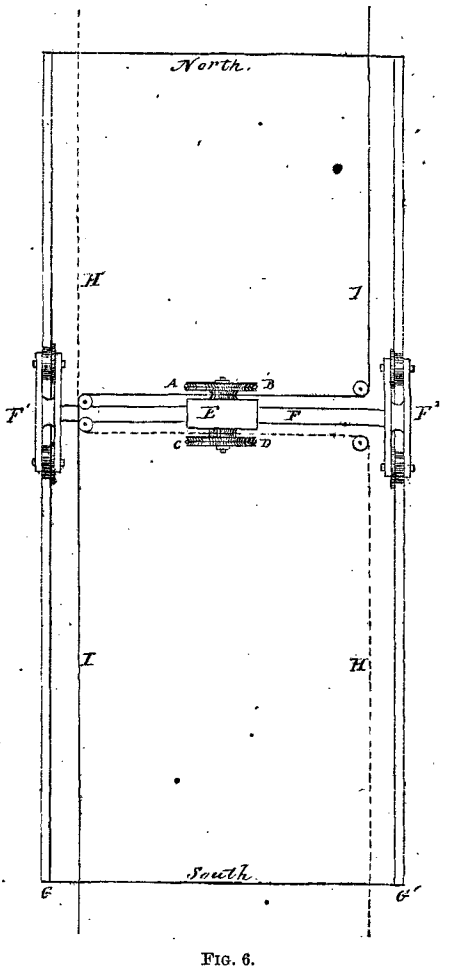


FIG. 6.

The drag of the idle sprocket wheel and attachments, upon the other cable, as the truck moves, tends to propel one end of the bridge towards the fixed extremity of that cable; the other end of the bridge is pulled parallel the same way, by the cable directly acted on. The two forces acting respectively upon the ends of the bridge are not equal, but are sufficiently so, to keep the bridge approximately at right angles with the railway. The direct traveling motion of the bridge upon the railway is square to the rails, with no tendency to jam, or run off, however wide the span, irrespective of the position on the bridge of the track which carries the sprocket wheels.

The disk-brakes used in the grapple dredging machines of the American Dredging Company, at Philadelphia, have 150 square feet of fric-

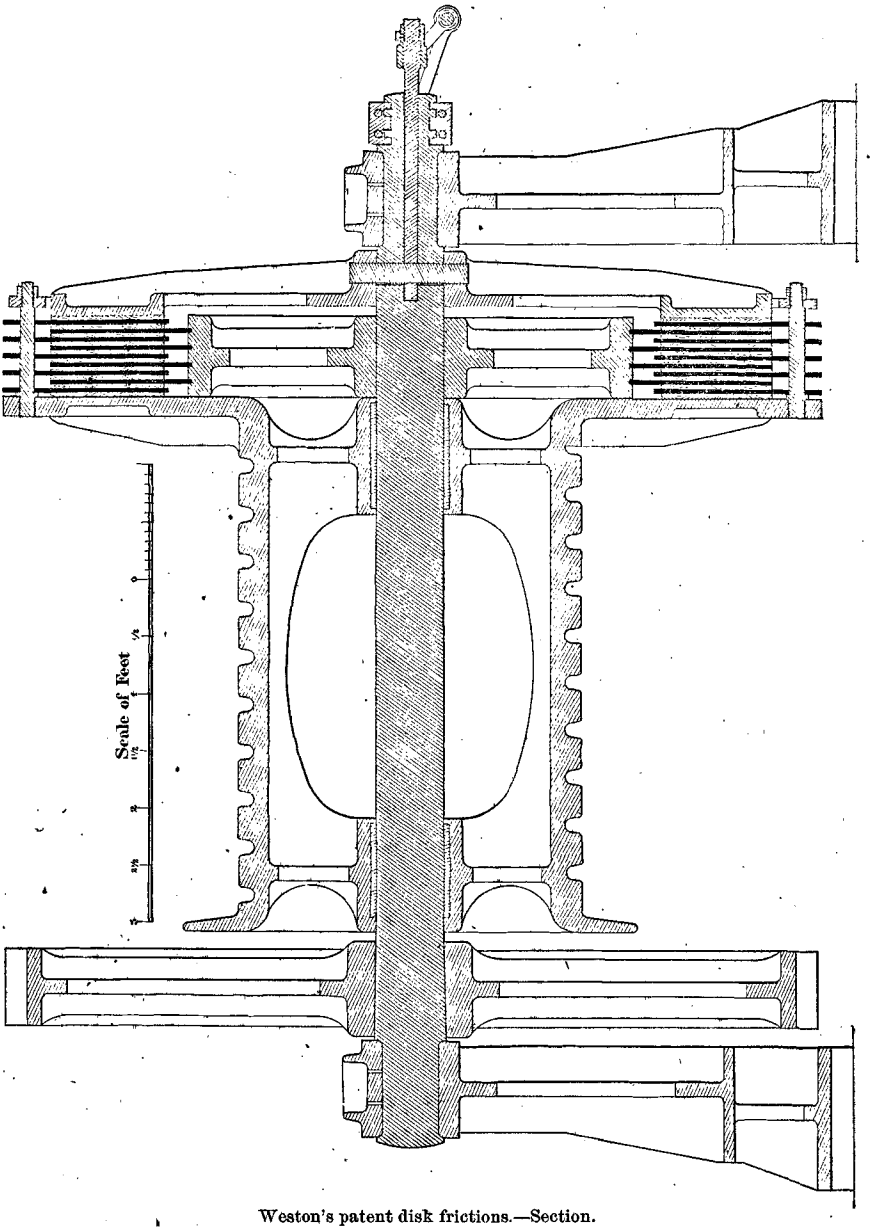
tion surface. The disks are between 6 and 7 feet in diameter. They are compressed by a "toggle" pinching apparatus, operated by a long lever. The chain worked thereby is of 1⅜-inch iron, and capable of carrying a maximum load of 30 tons. One man handles two of these drums with ease, controlling the descent of the load upon either chain with precision by direct friction. The wear upon these brakes is inappreciable. As the surfaces are flat there is no possibility of sticking, and the transmitted force is always a true and constant multiple of the initial pressure applied to compress the friction faces.

DISK FRICTIONS.

The apparatus consists of two series of friction disks, arranged alternately with each other upon a common axis, one series being carried by one shaft, and the other series connected to the other shaft or wheel which is required to be coupled with the first shaft. The disks on the the first shaft cannot turn independently of it, but can slide lengthwise upon it towards or from each other; this series of disks are for convenience called the "shaft disks" in the following description. Arranged alternately with them are the disks of the other series, which have each a circular central opening sufficiently large to clear the shaft entirely, but at their outer edge they are slotted or made polygonal or otherwise fitted in their outline to an external drum or cylinder containing them, so that they cannot rotate independently of the drum, but may slide longitudinally within it. These disks are called for distinction "the intermediate disks," and the drum containing them forms part of the spur-wheel that is required to be connected to the shaft with a coupling or break action, or the drum is attached to a second shaft lying in line with the first, with which the second shaft is required to be coupled. So long as no longitudinal compression is applied to the disks, the shaft disks with the shaft carrying them are free to rotate independently of the intermediate disks, and the drum containing them; but upon compressing the disks together longitudinally into frictional contact, the rotary motion of one series is either transmitted wholly to the other series or is controlled or arrested by friction against the disks of the other series, and the double series of disks acts thus either as a coupling or as a brake. The great advantage arising from the alternate arrangement of the disks is that the frictional effect of any pressure applied to couple them is repeated as many times as there are disks in the two series; that is, the number of all the disks is a constant multiplier for the friction produced between a single pair of the rubbing surfaces by any given pressure.

It may be remarked as an illustration that this principle of the repetition of frictional surfaces is the basis of the structure of ordinary hempen ropes. In that case contiguous fibers present their surfaces to each other in frictional contact, and the frictional adhesion between them is due to the initial pressure given by the original twist in the

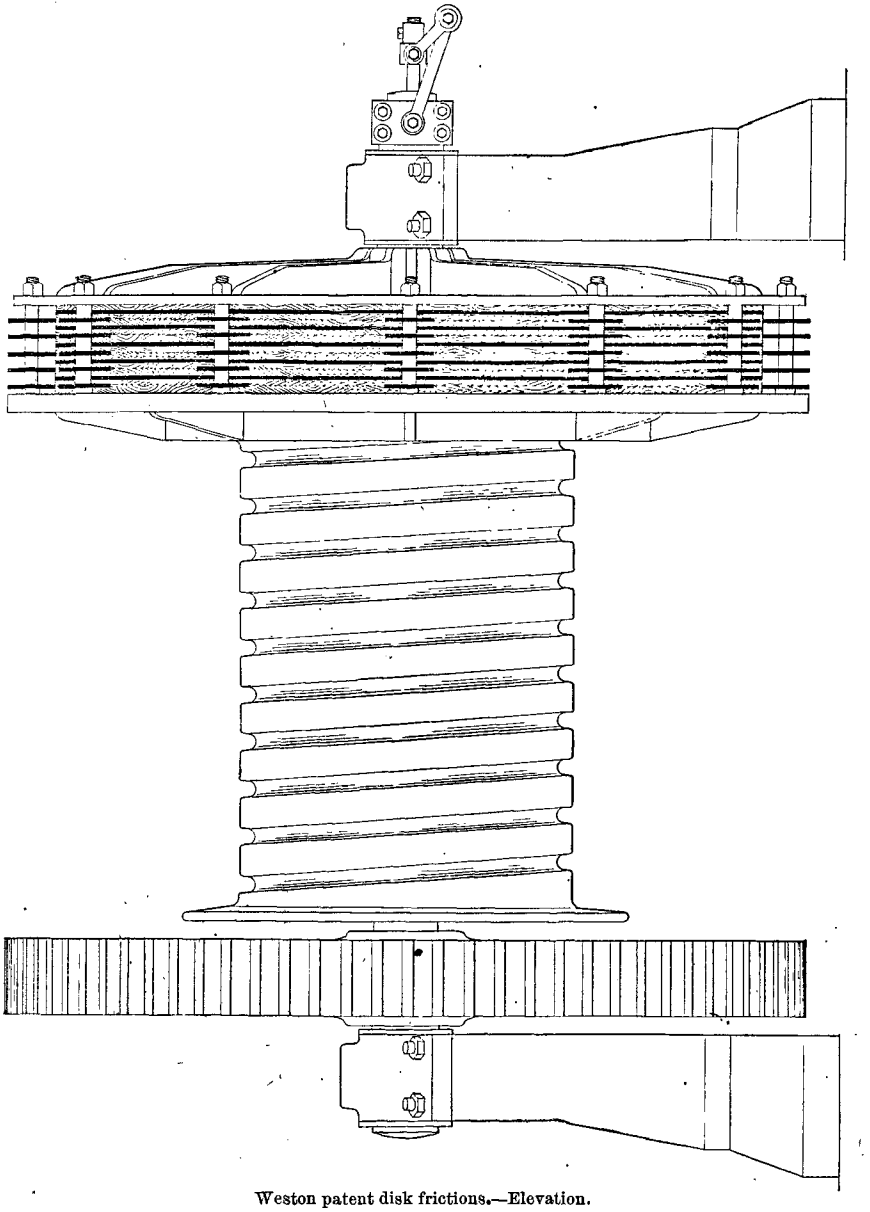
strands, and to the resultant pressure arising from the oblique direction of the strain upon the fibers under a load; and a rope of an inch diameter is stronger than ahalf-inch rope because of the greater number of fibers



Weston's patent disk frictions.—Section.

in frictional union which it contains. The "coupling" pressure upon the fibers may be wholly removed by completely untwisting the strands of the rope; and the strength of the rope will then have disappeared simultaneously with the loss of the frictional union of its fibers.

The materials and structure of the disks may be very various. For the severest strains both series of disks are made of iron, one series being faced with wood segments placed endwise of the grain. A coupling



Weston patent disk frictions.—Elevation.

capable of very high duty, and one very compact in form, is attained by employing thin sheet steel for the material of both series of disks, and facing one series with leather faces on both sides, the leather being attached by fine copper wire passed through small holes in the steel disks.

For brake purposes iron and wood disks are employed, and the wood disks are thoroughly saturated with linseed oil and the iron disks made smooth; the wear of the disks then becomes imperceptible. In consequence of the large amount of rubbing surface obtained, the lowest coefficient of friction suffices, and the brake may therefore be always lubricated, if desired, and is still sufficiently powerful. The pitch line or center of friction of the disks is the circle dividing their working faces into two annular areas. By enlarging the central opening in the intermediate disks, so as to make their working face a narrow annular ring, the pitch line is thrown further outwards from the shaft, and the power of the coupling is thereby increased, by increasing the leverage at which it acts; but for brake purposes this reduction of the actual area is not always desirable, as it reduces the amount of wearing surface, though increasing the efficiency of the brake.

For a coupling required to transmit motion and to cease doing so instantly at definite points in a revolution with exact precision, the intermediate disks are sprung apart by means of small springs placed near their edges, and the shaft disks are sprung apart by small spiral springs in their bosses. This plan of springing the disks apart when the pressure is withdrawn renders the coupling applicable to vertical or inclined shafts, or to a shaft having other motions than simply round its own axis. By employing springs of graduated strength between the disks, a coupling or brake may be arranged for obtaining a gradually increasing frictional action by making only one pair of faces come into action first; and during the time that this one pair only is in contact the frictional action between them can be gradually augmented by a gently increasing pressure, until the springs separating the next pair of disks are sufficiently compressed to bring these also into action, and so on until any required number of disks are in action. When all the disks have thus been brought into action the frictional resistance of a brake constructed upon this plan will still continue to increase under a further increase of pressure, until all relative motion between the two series of disks has ceased. This arrangement for bringing the disks successively into action will give a graduated effect, uniformly increasing by delicate and scarcely perceptible grades up to the full power of the brake; and it might be advantageously applied for such purposes as arresting rapid rotation in centrifugal drying machines.

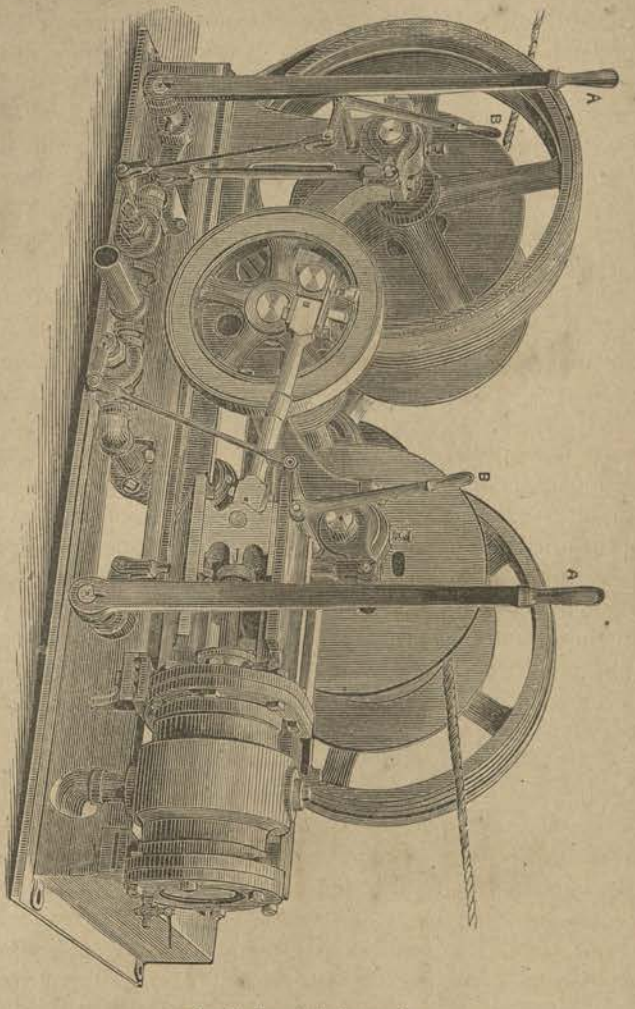
WILLIAMSON BROS., PATENT FRICTION HOISTING ENGINES.

Corner Richmond and South streets, Philadelphia.

The manufacturer claims that it is easily worked, very durable, and noiseless in working. Only one lever is required to be operated for hoisting and lowering, and with the governor valve attached, the same lever operates to slow down the engine immediately the break is thrown on.

The operation for ordinary hoisting is as follows with the governor-valve attachment:

See that the lever is thrown over, so that the break is on, and the wheels out of gear.



Double drum hoisting engine.

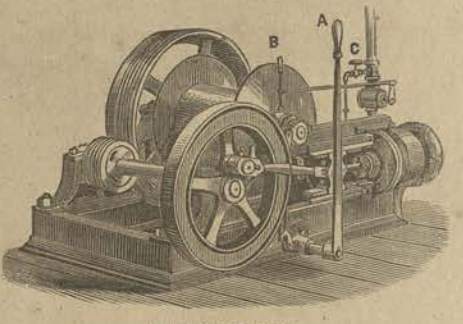
The stop valve, letting steam from the boiler, is then opened; but no steam can enter the cylinder, as the governor is shut when the break is on; the starting cock, which admits the steam between the governor valve and cylinder, is then opened sufficiently to allow the engine to run slowly, and it is ready for hoisting.

The lever, being moved over, brings the gearing together, at the same time opening the governor valve, which allows all the steam that passes

through the stop valve to enter the cylinder, and the load is thus raised at any required speed, due to the opening of the stop valve.

When the load is at the required height, the lever is thrown back on the break, the governor valve at the same time shuts off the steam, and the engine slows down; then, by easing up on the lever the break allows the load to lower at any speed that is desired, whilst the engine is at the same time running ahead slowly.

This engine can be made with a long shaft connection, so that any



The deck hoister.

number of hoisting drums can be run off it without changing the motion of the engine. A pump or other machinery can also be attached, which will not interfere with the hoisting, as the engine is always running one way.

The drums of the double-drum engine work independently of each other, the operation of each being the same as above described.

These engines are adapted for general hoisting, as deck hoisters, wharf purposes, miners' and contractors' uses.

HYDRAULIC PRESSES.

COMPOUND HYDRAULIC PRESS.

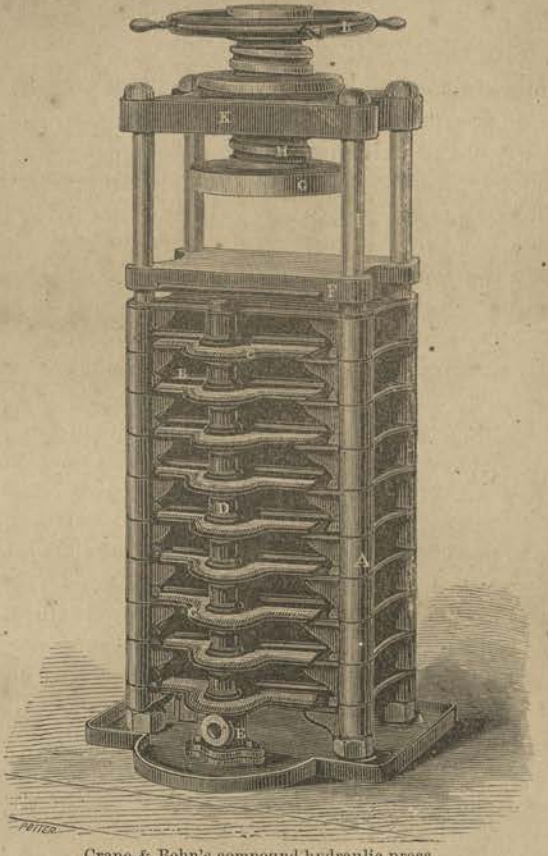
Manufactured by Bohn, Crane & Co., Newark, N. J.

Peculiarities.—It consists of a series of iron shelves, five to ten in number, connected together by rods and sustaining a series of flexible bags. These bags are connected by tubes and have a pipe leading to the tank or water supply into which steam can be admitted at 50 pounds or any required pressure.

When the water is turned on it flows into all the bags at the same pressure; on each bag lies an iron plate connected by vertical projections to the plates above and below. If there are 50 pounds' pressure, a 10-inch bag will lift 5,000 pounds, and ten such bags 50,000 pounds.

Advantages claimed.—It uses low pressure and is consequently free

from all leakage, loss of power, and troublesome packings; it has neither pump, crank, valves, or belt to get out of order; it has large water passages, and moves up to its work the moment the water is turned on; if neither steam nor water pressure is available, a common



Crane & Bohn's compound hydraulic press.

force-pump can be attached by which the requisite pressure of 50 pounds to the square inch can be obtained.

These presses are of short stroke, 2 to 6 inches, and are therefore provided with either a screw adjustment in the head or an auxiliary movement for the platin to clamp the material before the pressure is applied

LITHOGRAPHY.

METHOD FOR REPRODUCING MAPS AND DRAWINGS, BY CHARLES ECKSTEIN,

Technical director of the War Office at the Hague, the Netherlands.

The usefulness of chromo-lithographic maps is universally acknowledged, but the great number of stones required for printing numerous shades and the use of skilled workmen make them costly.

In the Eckstein process the tints and shades form themselves and the number of stones as well as of primary colors is limited to three, the first for blue, the second for yellow, and the third for red.

The stones are prepared as follows:

On each stone is printed a photograph of the map or drawing to be reproduced. The stone is then polished and coated with a mixture of wax, asphalt, stearine, and soda, forming a thin film. It is then covered with parallel lines in two directions by means of a line-drawing machine which removes the coating without cutting the stone. These lines are from .005 to .0002 of an inch apart. The parts to be left white are coated with asphalt and the stone subjected to an acid bath for half a minute.

The stone is now washed and dried, and those parts which are to be etched but once, as representing the lightest shades, are covered with lithographic ink to prevent further etching and to prepare the cross lines for receiving printing ink.

The second shade is obtained by exposing the stone to the action of the acid but for one minute longer. The stone is washed and dried and this shade is covered with lithographic ink as before, and the operation continued till the last shade is obtained, after which the stone is washed in turpentine and all the asphalt and ink removed. The stone is then ready for printing.

As the acid corrodes the stone very evenly the cross lines give a level tint deepening with each etching.

The operation can be performed by rather inexperienced hands, the covering of the sufficiently etched parts being done with a hair pencil; only the corroding or etching process requires strict attention as the variety of shades is entirely dependent on this part of the work.

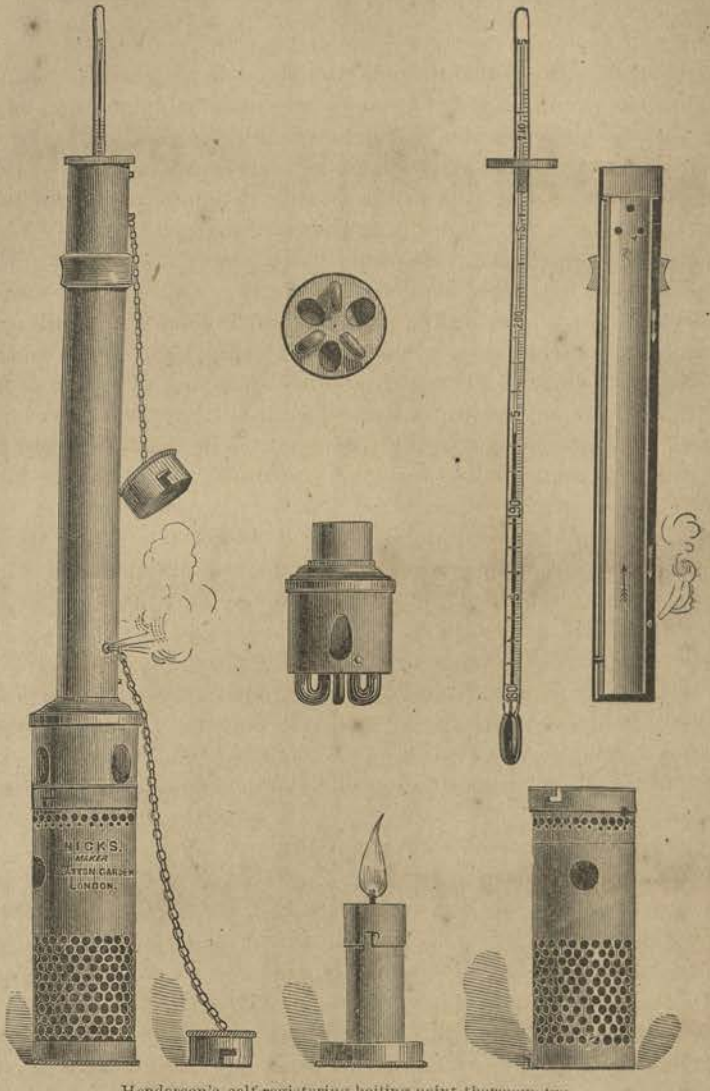
Every tint can be obtained by superimposing two or three colors of different strength. Equal shades of blue and yellow give green; a light shade of yellow on blue and red gives gray, and so on.

On the exhibited map there were 228 different shades of color printed from three stones. And the shading on some copies of photographs in one color was excellent; at a short distance the copies might easily be mistaken for the photographs themselves, only the outlines are sharper and clearer, like an engraving.

METEOROLOGICAL INSTRUMENTS.

HENDERSON'S SELF-REGISTERING BOILING-POINT THERMOMETER.

Made by James F. Hicks London.



Henderson's self-registering boiling-point thermometer.

The difficulty of replacing an exhausted supply of spirit for the lamp, and the probability of waste by spilling, are familiar to those who have made hypsometrical experiments. The apparatus, of which a cut is here given, has the following advantages:

1. The water is made to boil by the heat of a candle, which gives a uni-

form source of heat; and a measured quantity of water (about one-quarter ounce being used, the results are extremely uniform. Composition candles are easily carried, and are now obtainable almost everywhere. The piece of candle, about two inches long, which is used for boiling the thermometer, is pushed up by means of a spiral spring, as in an ordinary carriage lamp.

2. The thermometer is a self-registering maximum one, which can be carried to some distance without moving the index.

3. The brass tube in which the thermometer is boiled forms the case for carrying it in the pocket.

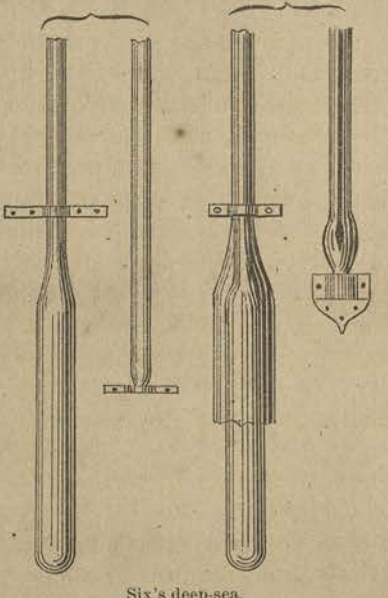
4. To prevent the detached piece of mercury, which forms the index, from being shaken down into the bulb, the thermometer is made with a constriction just above the bulb, but should the index, in spite of this arrangement, coalesce with the bulk of the mercury in the bulb, the instrument may again be made self-registering by gently tapping the bulb of the thermometer on the palm of the hand until a small portion of mercury breaks off into the neck. The operation requires some delicacy and dexterity, but may be performed with due care.

Henderson's boiling-point apparatus, complete with one thermometer, £2 7*s.* 6*d.*

Extra thermometer, in India-rubber lined metal case, 15*s.*

DEEP-SEA THERMOMETERS.

There are three modifications of thermometers for the registration of



Six's deep-sea.

deep-sea maximum and minimum temperatures, but that at present in general use in the Royal Navy (on board H. M. S. Challenger) is a modification of Six's.

In the earlier experiments made for ascertaining the temperature of the ocean at a depth of 15,000 feet, where the pressure is equal to three tons on the square inch, it was found that a considerable error occurred in the indications in consequence of this enormous pressure; accordingly, the central elongated bulb of the ordinary Six's thermometer is shortened and inclosed in an outer bulb nearly filled with spirit, which, while effectually relieving the thermometer bulb from undue pressure, allows any change to be at once transmitted to it, and thus secure the registration of the exact temperature. The arrangement possesses the further advantage of making the instrument stronger, more compact, and more capable of resisting such comparatively rough treatment as it would receive on board ship.

Deep-sea maximum and minimum registering thermometer as described, in ebonite mounting, divisions and figures on German silver, raised scales at side, acting also as a protection to the thermometer, in round copper case, with hinged door and clasps, £1 10*s*.

Johnson's deep-sea metallic thermometer depends for its indications on the unequal contraction and expansion of compound metallic bars. Strips of brass and steel are riveted together, and when heated the brass expands more than the steel, the bar will be found to assume a slight curve in one direction, while a contraction of the brass in excess of the steel from the reduction of temperature will impart a curve in the opposite direction. £4 10*s*.

NEGRETTI AND ZAMBRA'S PATENT DEEP-SEA SELF-REGISTERING THERMOMETER.

This contrivance has no indices or springs, and its indications are by the column of mercury only. The bulb of the thermometer is so protected as to resist the pressure of the ocean, which varies according to depth, being at 3,000 fathoms about 3 tons on the square inch. This instrument is, in shape, like a siphon, with parallel legs all in one piece, and has a continuous communication, as in the accompanying Fig. 1. The scale of the thermometer is pivoted on a center, and is attached in a perpendicular position to a simple apparatus. In its descent the thermometer acts as an ordinary instrument; but as soon as the descent ceases, and a reverse motion is given to the line, the instrument turns once on its center, first bulb uppermost, and afterwards bulb downwards. Fig. 1 shows the position of the mercury after the instrument has been thus turned on its center. A is the bulb; B the outer coating or protecting cylinder; C is the space of rarefied air, which is reduced if the outer casing be compressed; D is a small glass plug which insures that none but the mercury in the tube can be transferred into the indicating column; E is an enlargement made in the bend, to enable the mercury to pass quickly from one tube to another in revolving; and F is the indicating tube or thermometer proper. When the thermometer is put in motion, and as soon as the tube has acquired a slightly oblique position (Fig. 2), the mercury breaks off at the point D, runs into the

curved and enlarged portion E, and eventually falls into tube F, when this tube resumes its original position. The contrivance for turning the thermometer over at the bottom of the sea is a vertical propeller to which the instrument is pivoted. The engraving (Fig. 2) shows the general

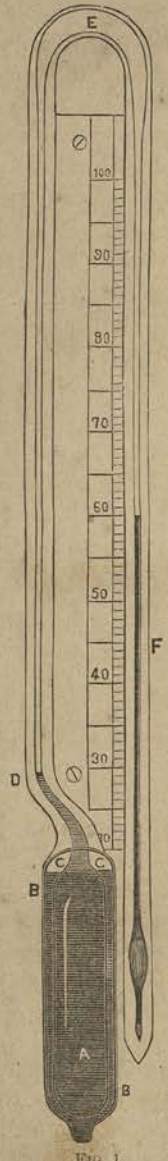


Fig. 1.

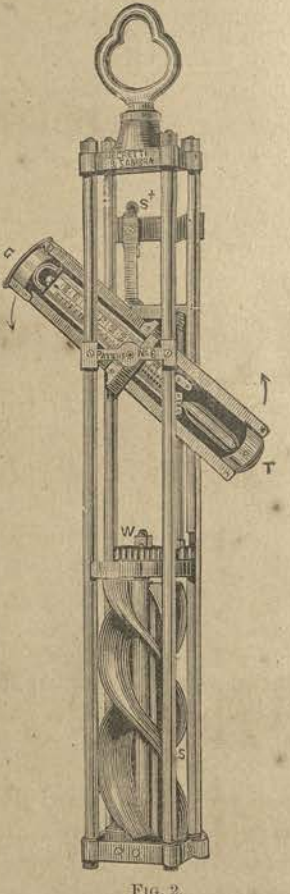


Fig. 2.

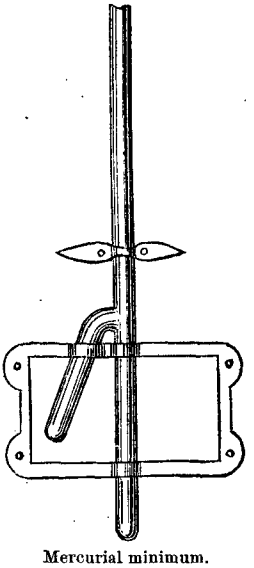
arrangement, T being the thermometer, S a metal screw connected with the frame of the thermometer by a wheel and pinion movement at W; S† is the stop for arresting the movement of the thermometer when it has made one revolution.

The same principle is used in making a self-recording thermometer which records the temperature at any given hour, day or night, that may be desired.

This thermometer is similar in construction to the deep-sea thermometer just described, the revolution in this case being effected by attaching it to a clock which is wound up and set to the desired time in the same manner as an alarm. This instrument will be found useful where it is desired to take observations at fixed hours in the absence of the observer and for the synchronous system about to be adopted at all meteorological stations throughout the globe.

MERCURIAL MINIMUM THERMOMETER.

The indications of this thermometer are perfectly reliable and it cannot be put out of order.



Mercurial minimum.

Hitherto alcohol only was used to ascertain minimum temperatures, although it was well known that for scientific investigation alcohol did not give accurate results. The sketch shows the construction of the bulb.

HICKS'S FLEXIBLE BULB MERCURIAL BAROMETER.

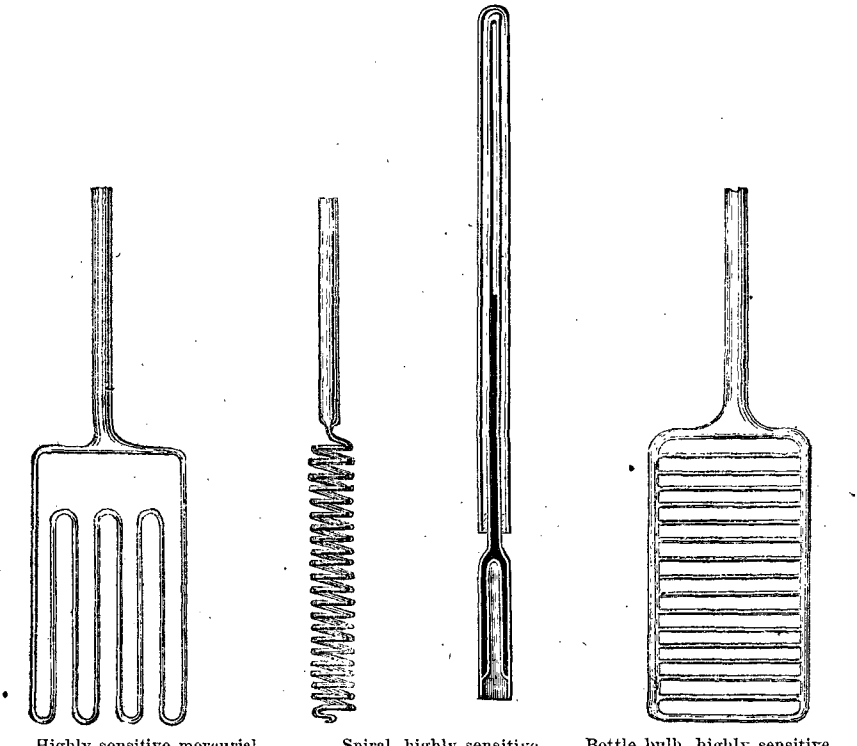
This instrument is constructed to meet the requirements of tourists and surveyors where portability, accuracy, and strength are desiderata. It cannot be put out of order except by actual breakage, and its weight does not exceed 1 pound. It consists of a flat bulb of flexible glass filled with mercury, exhausted of all air, and hermetically sealed at both ends. It looks like a thermometer with a very long tube; the pressure of the air is communicated to the mercury through the flexible bulb. The inches are divided on the glass tube itself, which is mounted

on a metal scale with small attached thermometer and sliding scale to compensate for temperature, and the whole is inclosed in a morocco or solid leather case. Price £5 5*s*.

HIGHLY SENSITIVE THERMOMETERS.

Made by Jas. F. Hicks, 8 Hatton Garden, London, E. C.

Mr. Hicks makes several highly sensitive thermometers, and accomplishes this result by the shape of the bulb. In mercurial thermometers he makes the bulb either spiral or in the shape of a gridiron; 100° F. extends over 18 inches on the latter instrument so that it can be read to one-tenth of a degree by direct observation.



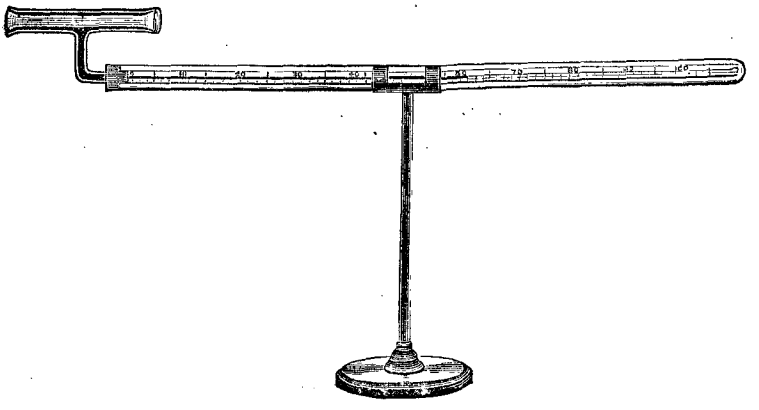
Highly sensitive mercurial. Spiral, highly sensitive. Gridirons highly sensitive. Bottle bulb, highly sensitive.

In spirit thermometers the bulb is either "bottle" shape or "cylinder-jacket" shape, the latter being most sensitive.

The bottle-shaped bulb is cylindrical, with the bottom pushed in as much as possible, an exaggerated imitation of some wine bottles. The air, or other fluid medium in which it may be exposed, acting upon the hollow as well as the outside surface, and the stratum of spirit between the glass surfaces being thin, the thermometer is found to be very sensitive.

The cylinder-jacket bulb consists of a long cylinder of glass, hollow,

and about which a second cylinder is blown and united at the open ends so as to leave a thin space between them to contain the spirit. The stem of the thermometer is connected to a middle point in the outer cylinder. In action it is the same as, but is far more sensitive than, the "bottle-bulb."



Cylinder jacket, highly sensitive.

Other thermometers depend for their sensitiveness on the shape of their bulbs, the most common forms being the gridiron and spiral, as shown in the cuts herewith.

PILE-DRIVERS.

SHAW'S PATENT GUNPOWDER PILE-DRIVER.

The Gunpowder Pile Driver Company, No. 10 South Delaware Avenue, Philadelphia, Pa.

The principal of action and manner of operation of this apparatus is as follows:

A small hoisting-engine hoists the ram and gun to the top of the machine, where the ram is held in place by the friction-brake. The pile is then hoisted into position and the gun lowered upon it, the recess at the lower end of the gun covering the pile-head and securely holding it in position directly underneath. A cartridge is then dropped in the gun, the operator releases the brake, and the ram falls with its piston entering the bore of the gun (which is made slightly funnel-shaped at the muzzle), and, by compressing the air, exerts a gradually increasing downward pressure upon gun and pile, till the inertia of both is more or less entirely overcome; the cartridge is crushed by the piston and ignited by the heat evolved by the sudden and severe compression of the confined air. An explosion immediately ensues, the result of which is to violently force the pile downward, and this action is measured by the reactionary effect upon the ram, the height to which it is thus thrown,

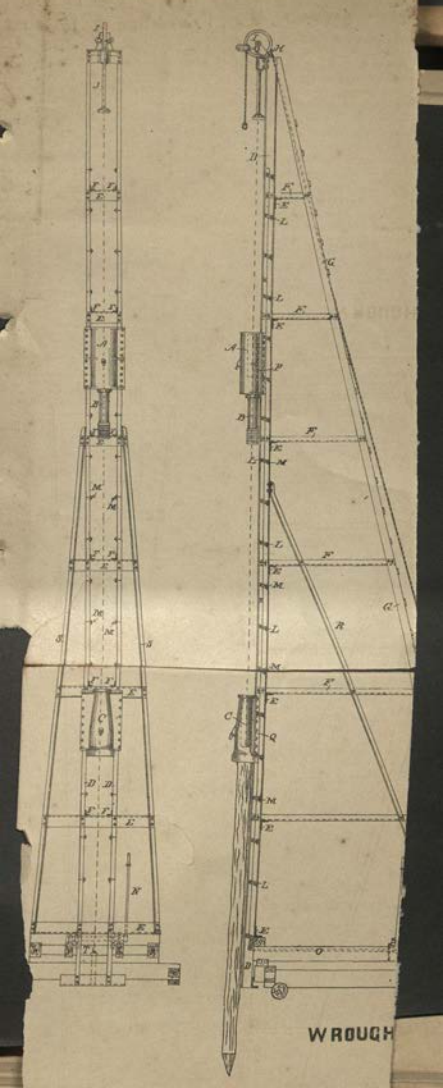
and from a state of rest practically, and applied to the pile while in motion. The force due to the fall of the ram, and the explosive force exerted to throw the latter again into position, are thus at once combined and applied to the pile.

The principal difference of effect between this method and the ordinary hammer appears to be this: In the one case the pile is already in motion when a tremendous force is suddenly brought to bear upon it in the same direction, and in the other case it receives a violent blow when at rest, and a considerable portion of the force is expended uselessly in the destruction of the pile-head itself before the inertia is overcome and motion produced. Hence the necessity of strongly banding the pile-heads in the latter case, and the utter absence of any necessity for their protection in the former.

The ram on its rebound is caught and held by the brake, and the operation repeated at pleasure. The cartridges are made of common blasting-powder, pressed into cylinders about $1\frac{1}{4}$ inches in diameter, weighing from 1 to $1\frac{1}{2}$ ounces each, and coated with paraffine and plumbago, and are supplied by hand, being tossed into the gun in advance of each blow.

The enormous power developed by the explosion of confined gunpowder, as used in this process, calls, in the first place, for a strong and rigid framing to resist the sudden and severe strain imposed upon the guides when the apparatus is at work; and the close-fitting plunger entering the gun at every stroke requires a good degree of precision in the fitting of the guides upon which the ram and gun travel; while the application of a friction brake to arrest and retain the heavy ram in position, at any point in its travel, involves the use of a special application for this purpose, and the consideration of other strains incidental to its use and to which the framing itself is subjected when not in operation. Manifestly the ordinary pile-driver frame is not adapted to this new order of things, and several attempts have been made, since this discovery, to produce a suitable framing that would satisfactorily fulfill all the requisite conditions without being unwieldy, and at a moderate cost. The principle involved in the process, and the efficiency of its action, were fully demonstrated at the outset, and to successfully harness this powerful engine and place it in practical operation, under safe and easy control, in order to utilize its power—a question of mechanical construction alone—has been the problem under solution ever since.

Referring to the drawings, *A* is the ram of cast iron, provided with its plunger, *B*, upon the lower end of which is screwed a steel ring or band and turned to neatly fit the bore of the gun below, the whole weighing 1480 pounds. *C* is the gun of steel manufactured by the McHaffie process and weighing 1,000 pounds. It has a bore $6\frac{1}{4}$ inches in diameter and 24 inches deep, pointing upwards, with its mouth slightly bell shaped to receive the ram-plunger at each stroke. Its walls are $3\frac{1}{4}$



WROUGH

inches thick at the base, and the lower end is recessed to receive the head of piles. *D*, *D* are the uprights of the frame, each consisting of a single piece of 6-inch channel bar of rolled iron 45 feet long, and weighing 37 pounds per yard, with their flanges turned outward and the front flanges forming the guides or ways up and down which both ram and gun move. The uprights are firmly secured together, the proper distance apart by means of angle-iron cross-bars, *E*, riveted to the rear flanges, and spaced 6 feet apart. The side bars, *F*, of the framing are of angle-iron also, one end of each bar being bolted through its vertica flange to the inside of the web of the uprights, and to the upper flange of the cross-bar through its horizontal flange, thus forming a sort of gusset stay or brace to stiffen the guides transversely while the other end is bolted to the ladder *G*, which is made of wood. The cross-head *H*, at the top of the frame, carries the runner shears *I*, and cushioning piston *J*, bolted to its upper and under sides, respectively. This fixed piston fits into a corresponding bore of the ram to form an air cushion and prevent the escape of the ram from the guides when the weight of its rebound is limited, as during the first blow with long piles.

The friction-brake attachment, by which the ram is held in position at any point, is located (one on each side of the machine) between the flanges of the uprights, on the outer side, and consists of a brake-bar, *K*, made of very light T-iron, and brake-arms, *L*, made of McHaffie steel, &c., spaced 2 feet apart, and pivoted to the studs *M*, in the web of uprights, and is operated by the lever *N*, through the link *O*. By this arrangement of the brake it is well protected from injury while at work; the connections are short and direct, and the strains of its action are self-contained in a single part of the machine. The friction surface of the bar and guide are likewise effectually protected from any fouling action from the gun.

To facilitate the tool-dressing and accurate fitting of the jaws of the gun and ram to this particular sectional form of guides, wrought-iron plates, *P* and *Q*, are bolted to their rings or arms to form the inside lips of the jaws, as shown. The plates *P*, of the ram, against which the brake-bar bears, are made a little thicker than those of the gun, so that the brake can be applied to the ram only. The sills of the framing are of wood, and rest upon the long rollers ordinarily used on land machines to facilitate their movement. The pile-driver frame proper pivots about the pin *T*, in the bed-frame, upon which it rests, affording a limited lateral movement without sliding the whole machine upon the rollers as is usually done. By this means four or five parallel rows of piles may be driven along together without moving the machine forward, backward, and sidewise for every other pile in alternate rows.

The hoisting-engine is placed upon the bed timbers of the rear, and is provided with a winch head so that all the necessary forward and lateral movements may be easily accomplished by steam-power. The diagonal angle-iron braces, *R* and *S*, are merely to give additional stiffness to the framing.

The principal advantage or improvement claimed in the design is the overcoming many of the mechanical difficulties which have been in the way of producing a much higher and cheaper machine, consistent with the requisite strength, efficiency, and durability. Ordinary rolled iron has therefore been largely used in its construction, it possessing all the necessary qualities. Moreover, the uprights can be made in a continuous piece, without any joints or bolts incident to the use of cast iron or steel in sections, and, unlike them also, the guides require no machine-fitting or tool-dressing, while its superiority over cast iron in every essential respect is sufficiently obvious without further comment. By this plan a large saving in cost of construction is effected, as well as a reduction in weight.

It will be observed that the jaws of the ram and gun literally grasp this form of guides, forming a bearing on each of their four faces, so that the uprights support each other, all side thrusts or strains in either direction being thus communicated to them both and borne in common.

To facilitate its being taken apart for transportation, the side bars are only bolted in place, and by their removal the frame is readily taken down.

PROPELLERS.

FOWLER STEERING PROPELLER.

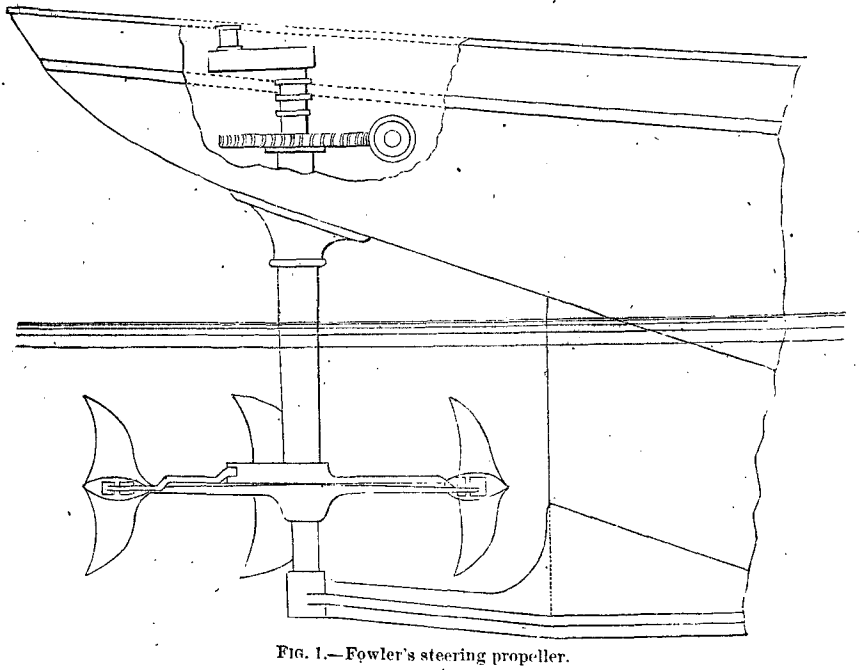


FIG. 1.—Fowler's steering propeller.

This propeller is hung on a vertical shaft (Fig. 1.) which passes down through the overhang at the stern of the vessel, and is supported at its lower end by a step or water-bearing attached to a prolongation of the keel.

To the upper end of the shaft a horizontal engine may be attached directly, in which case the pillow-block will form the upper support of the shaft. But if it is desired to locate the engine in the middle of the boat, it can be done by turning the shaft with a properly-constructed universal coupling.

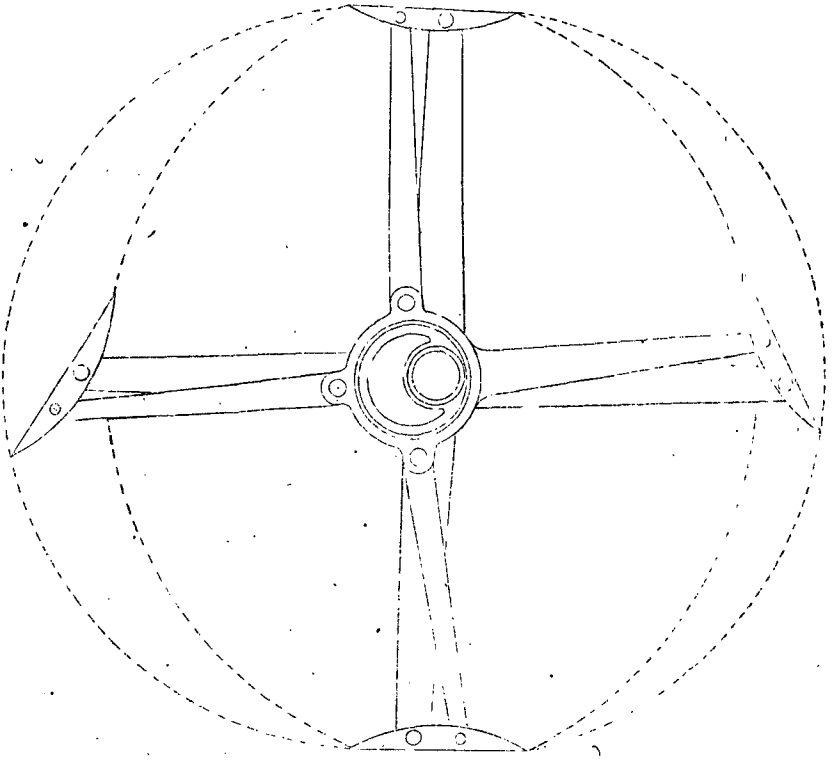


FIG. 2.

The propeller is formed by horizontal arms (Fig. 2.) radiating from a shaft, on the extremities of which are hung vertical blades. In smooth water a single arm, attached to the center of the blade, is sufficient, while in rough water it is desirable to have the blade supported by an arm at each end. The blades are hung on a pivot so as to admit of an oscillating motion, which is produced by an eccentric, to the strap of which each blade is connected by an additional arm. This oscillating motion causes the blade to feather as it revolves, so as to produce a propelling effect, pulling on the forward half of its circuit, and pushing on the after half.

This propulsion is identical with that of a fish in swimming (Fig. 3), the blade having the same travel as the fish's body, and it is effected without loss or drag. It is rendered very effective by the fact that the water is not lifted by centrifugal action, nor can the wheel run itself dry by the excessive application of power, as the water can feed from above and below as well as from ahead. Besides, there is not the resistance of a hub, rudder, and a thick run of the vessel.

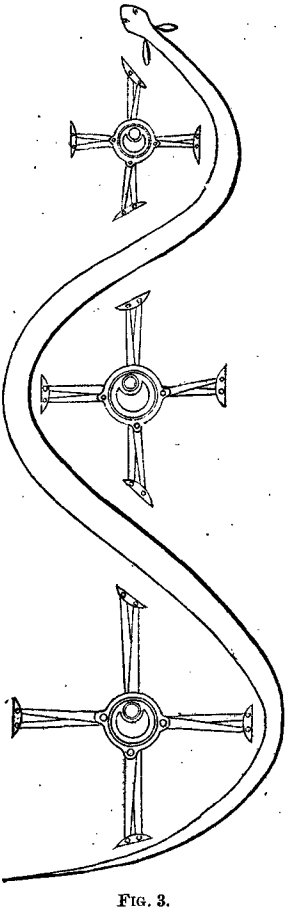


FIG. 3.

Steering and maneuvering.—The propelling force is always directed in the direction of the short radius of the eccentric above mentioned. This eccentric is attached to a hollow shaft through which the propeller shaft passes. This hollow shaft passes up through the vessel and terminates in a worm-wheel with which the helm is connected. The steersman can, by turning the helm, turn the eccentric and thereby cast the propelling force to any point of the compass, by which means he can steer the boat, turn her on her center, back her, and perform a variety of useful evolutions that can be performed by no other vessel;

and this, too, without reversing the engine, as the propeller always revolves in one direction, no matter what evolution is required.

Among the maneuvers that this propeller can perform may be enumerated:

1. The ability to turn a boat rapidly on its center and in its own length of water an indefinite number of times, either to the right or left, and changing suddenly from one to the other.

2. To wind a boat at the dock in from thirty to one hundred seconds, depending on the size of the boat.

3. To pass out of a slip when the vessel has neither room to back or go ahead, by squaring ahead sideways.

4. To pass around two piles, placed half the length of the boat apart, so as to describe a figure 8, both in going bow first and in going stern first.

5. To follow a narrow channel, having a serpentine course, at full speed when backing.

6. To stop the boat when going at full speed, in going her length.

The steersman is guided in the manner of turning the helm by a steering index which points out to him the direction of the thrust of the propeller, and the manner in which the wheel should be turned to produce a given evolution. For example, if it is desired that the boat shall move ahead the index is made to point ahead by turning the helm; and so of any other evolution.

Lightness of draught.—The Fowler wheel has but half the draught of water of the screw propeller. It is well adapted to shoal water on this account, and it is very well adapted to rough water, as it can be put so low in the water that it will not lift out as the vessel pitches, and it is not liable to be deranged by coming in contact with ice floating on the surface.

PUMPING MACHINERY.

The display of pumps is very large and includes pumps of every description and for all purposes. Only those will be mentioned which are specially suitable for engineering purposes, such as for emptying caissons, graving docks, &c., reclamation of submerged lands and the like.

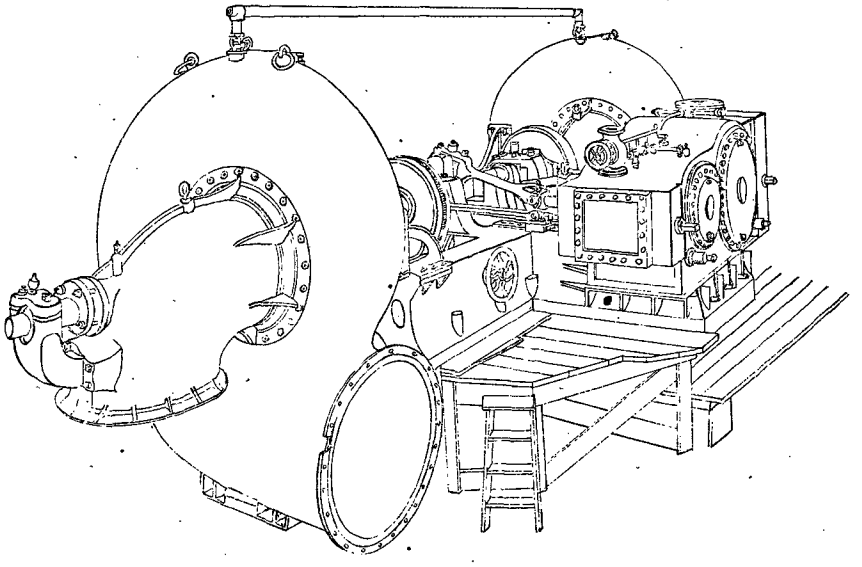
One of the exhibits deserves special mention as it is a model of the largest pumping machinery in the world, erected at Ferrara, Northern Italy, 1873–'4. In describing it I copy from the catalogue of the makers, John and Henry Gwynne, Engineers, 89 Cannon street, E. C., London, England.

The sketch (page 554) shows *one* set of these enormous Pumping Engines, which are indisputably the largest set of pumping machinery in the world. The following description of this machinery appeared in "Engineering" of July 25, 1873:

A few months ago we briefly recorded the fact that Messrs. John & Henry Gwynne, of the Hammersmith Iron works, Hammersmith, had commenced the construction of by

far the largest set of centrifugal pumping machinery yet undertaken, this machinery being intended for employment on the reclamation of the Ferrara marshes, in Northern Italy. The tract to be reclaimed extends over an area of nearly 200 square miles, and the work to be done by the pumps consists in raising a little over 2,000 tons per minute for a mean lift of 7 feet 3 inches (the maximum lift being about 12 feet), and delivering it into the river Volano, at Codigoro, where the pumps are to be erected. To perform this work, Messrs. John & Henry Gwynne are constructing eight pumps, these pumps being disposed in pairs, and each pair being driven by a pair of compound engines. The first pair of these pumps, with their engines, have just been completed, and during the present week we had an opportunity of inspecting them at the works of the makers, prior to their shipment to Italy. Quite apart from their exceptionally large size, these engines and pumps are, as respects design and workmanship, perfect models of their class, and some particulars of them will therefore be regarded with interest by numbers of our readers. We may add that on a future occasion, when the works are further advanced, we hope to illustrate the arrangements fully.

It is a very simple matter to state that certain pumps have to raise 2,000 tons of water per minute, but it is more difficult to appreciate what such a performance really means; and before describing the Ferrara pumping machinery, therefore, we



propose to state a few facts which will enable our readers to obtain a clear idea of the work to be done. When working at the mean lift of 7 feet 3 inches, each of the eight pumps is constructed to discharge 57,000 gallons per minute, the aggregate discharge from the eight pumps when working at this lift being consequently 456,000, or or nearly half a million gallons per minute. But 456,000 per minute equals 656,640,000 gallons per day of twenty-four hours, while, according to the latest return, the total quantity of water supplied by the whole of the London Water Works is a little under 110,000,000 gallons per diem, so that it will be seen that the quantity of water to be dealt with by the Ferrara pumping machinery amounts to six times the whole metropolitan water supply. Again, 456,000 gallons, or 72,960 cubic feet per minute would supply a stream over 103 feet wide and 4 feet deep, running at a speed of two miles per hour, or 176 feet per minute, while the delivery for a single day would also suffice to fill a reservoir a mile square to a depth of about 3 feet 9 inches. Lastly, we may mention that in 1852 when several important water works acts were passed, the minimum quantity of water passing down the Thames above Hampton was estimated

at 362,000,000 gallons per diem, while in September, 1865, observation showed a minimum quantity of a little over 300,000,000 gallons per day; this latter quantity being less than half that to be lifted by the Ferrara pumping machinery. These facts will, we trust, give a fair idea of the quantity of water to be dealt with, and we must now speak of the machinery itself.

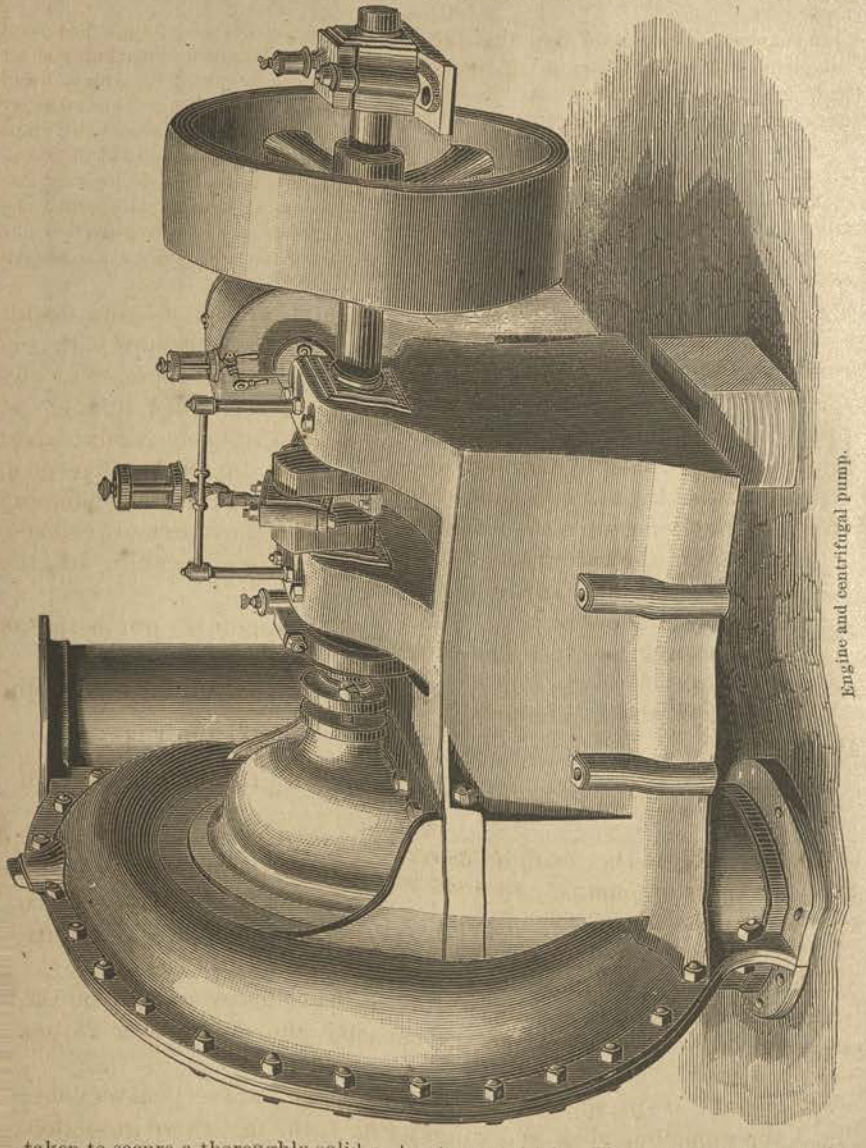
There are, as we have said, to be four pairs of pumps, each driven by a pair of compound engines, each pair of pumps with its engines being entirely independent of the others. The bed-plate for each set of pumps and engines is made of three pieces, the center piece, which weighs 13 tons, carrying the engines complete. The two other sections of the bed-plate are securely bolted to the central piece, so as to form one solid mass, which, if the foundations fail in any way, must go altogether, without disturbing the alignment of the crank-shaft or pump-shaft bearings. The pumps are placed one on each side of the engines, the pump-shafts forming prolongations of the crank-shaft, and being connected to the latter by disc couplings, on which are keyed small disc fly-wheels, containing the balance weights, one of the wheels also being a worm wheel fitted with turning gear for turning the pumps by hand. This is an exceedingly neat arrangement.

The pump-shafts are of steel, about 8¼ inches in diameter, and are provided with bearings beyond the pump-casings. The pumps have 5 feet disks, and suction and delivery pipes 54 inches in diameter, the suction passage passing through the bed-plate directly under the pump, and branching to enter the pump-casing on each side. The arrangement is such that by simply removing the top bend of the outer suction branch, the disc can be examined, or, if necessary, removed, without interfering with the pump-casing or other pipes, the facilities for examination being, in fact, excellent. The volute or casing of each pump is made in a single casting, some 15 feet in diameter—a very bold piece of work, which has been successfully accomplished.

The engines are, as we have stated, compound, and are of the intermediate receiver type. They have cylinders 27¾ inches, and 46⅝ inches in diameter, respectively, the stroke being 2 feet 3 inch. The two cylinders, together with the valve-chests and intermediate receiver are made in a single casting, and Messrs. Gwynne have designed and erected a very simple form of special boring machine, by which the two cylinders are bored out simultaneously, and perfect parallelism is secured. Both cylinders are jacketed, the jackets being formed by the insertion in each cylinder of a loose working barrel or liner, fixed by an internal bolted flange at one end, and provided with an expansion joint at the other. The valve-chests are on the outer sides of the cylinders, the high-pressure cylinder having an expansion valve on the back of the main slide; while the low-pressure cylinder has, as is usual, a single valve only. The cranks are not placed at right angles, but at an angle of about 130°.

The low-pressure cylinder exhausts into a pair of surface condensers, placed one on the discharge-pipe at each pump. Each condenser is simply a cylindrical chamber, having a tube-plate at each end, and traversed by a number of 3-inch tubes, short conical lengths of pipe connecting the tube-plates with the pump-casing and the prolongation of the discharge-pipe, respectively. Each condenser exposes 750 square feet of tube surface, and, as the tubes are traversed by the whole of the water discharged by the pumps, this surface will be very effective. The tube-plates, we may mention, are of cast iron, and have the tube-holes cast in them, the tubes projecting through the plates, and the packing simply consisting of an india-rubber ring slipped on the projecting end of each tube, and so spread as to form a joint between the tube and the plate. This form of packing has been employed by Messrs J. & H. Gwynne for similar condensers on former occasions, and it is found to act perfectly, while it is certainly extremely simple and easily applied. The air-pump, which is single acting, and is 19 inches in diameter by 12-inch stroke, is placed below the level of the engine-room floor, and driven by an eccentric on the crank-shaft between the two cranks. A sluice-valve is placed on each discharge-pipe beyond the condenser, this valve being worked by hydraulic power.

Of the general design and workmanship of these engines we cannot speak too highly, the latter being fully equal to that of the very best marine engine work we ever had an opportunity of inspecting. The pump-spindles, connecting-rods, piston-rods, and, in fact, most of the working parts, with the exception of the crank-shaft, are of Bessemer steel, and everywhere large bearing surfaces are provided, and every pains



Engine and centrifugal pump.

taken to secure a thoroughly solid and substantial job. There are many neat points in the design, too, which could only be appreciated from an inspection of the engines themselves, or from an examination of the drawings, and these we must leave to be made clear by the engraving which we hope to publish hereafter; but in the meantime we may state that the whole design is especially distinguished, not only by good proportions, but by the fewness of parts employed.

Steam will be supplied to the four pairs of engines by two groups of boilers, placed

one at each end of the building containing the pumping machinery. Each group consists of five boilers, these boilers each containing two flues or furnaces united into a combustion chamber traversed by Galloway tubes, while 108 tubes, 3 inches diameter by 4 feet long, extend from this combustion chamber to the back end of the boiler. Each boiler exposes 730 square feet of heating surface, and has 30 square feet of grate area.

In conclusion, we should state that the first pair of engines and pumps has been completed within eight months of the signing of the contract, a remarkably short time, when it is remembered that the whole design was a new one, for which drawings and patterns had to be got up, and that the whole of the castings were made by Messrs. J. & H. Gwynne themselves. The remaining three pairs of engines and pumps are to be delivered before the end of the year; and there are also in hand at the Hammersmith Iron Works some other large pumping machinery for the docks at Stockholm, Cadiz, and Cuxhaven, as well as for sewage works at Leeds. Altogether, the energy with which the work of which we have been speaking has been carried out reflects much credit on all concerned in it, and Messrs. J. & H. Gwynne are to be congratulated on the result.

The manufacturers state that for emptying dry and floating docks, caissons, coffer dams, or gas-tanks they can be recommended with confidence, being cheaper, and better adapted for the purpose than any pumping machine ever introduced. They have been fixed by them at Nieuw Diep, Newcastle, Sunderland, Greenock, Cuxhaven, Cadiz, Great Grimsby, Stockholm, Portsmouth; Clarence Graving Docks, Liverpool, &c., and they guarantee the following advantages over other pumping machinery: 1st, they are cheaper at first cost; 2d, they are more economical in their working expenses; 3d, they are more durable; 4th, the workmanship is superior.

One important use to which these pumps might be put is that of dredging sand.

The prices of these pumps will be furnished on application to the manufacturers.

ANDREWS' PATENT IMPROVED ANTI FRICTION CENTRIFUGAL PUMP.

This invention is the result of many years of experimenting with and use of all kinds of pumps. In 1846 was patented the pioneer of this class of machines, since widely known as the Gwynne pump, and extensively manufactured in England. In 1854 was patented the anti-friction centrifugal pump, which patent was extended in 1868.

The present invention is claimed to be a great improvement upon the last, reducing its cost, increasing its capacity, and saving over 25 per cent. in power.

Figs. 1 and 1′ are perspective views; Figs. 2 and 2′ are vertical sections; Fig. 3, the propelling disk and wings; Fig. 4, the foot-valve in section. Similar letters refer to like parts. The arrows show the direction in which the disk turns. A is the suction-pipe flange on chamber C, within which the disk K, with its wings 1 to 6, revolve without touching; to chamber C are attached the conducting cases DD^1, which form between them an easy, curved, spiral discharge passage, gradually enlarging towards its

outlet E. The shaft G, of cast steel, passes through stuffing-box F, and is fitted into a Babbitt-metal box in standard H and its cap *h*. Suction-pipes attach to flange A, and discharge pipe to flange *f*. The wings on

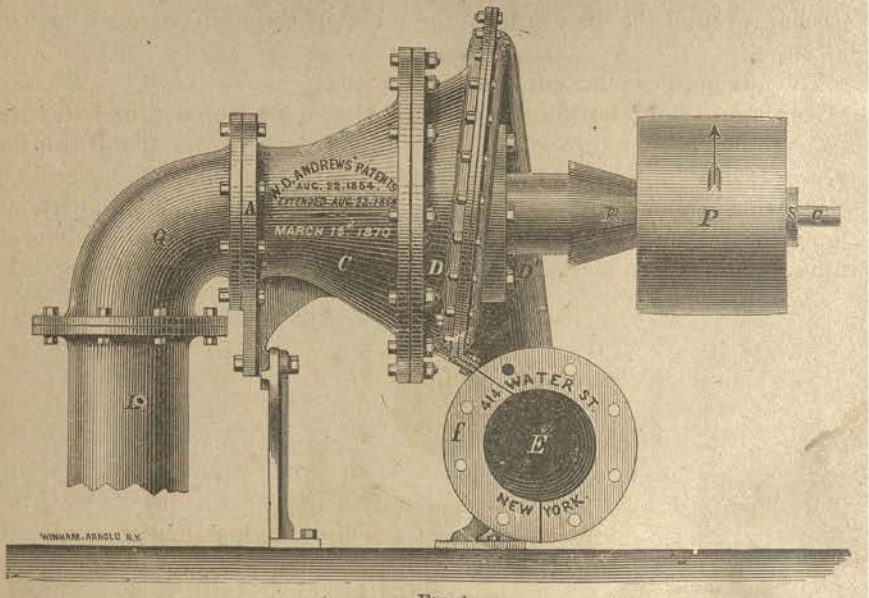


FIG. 1.

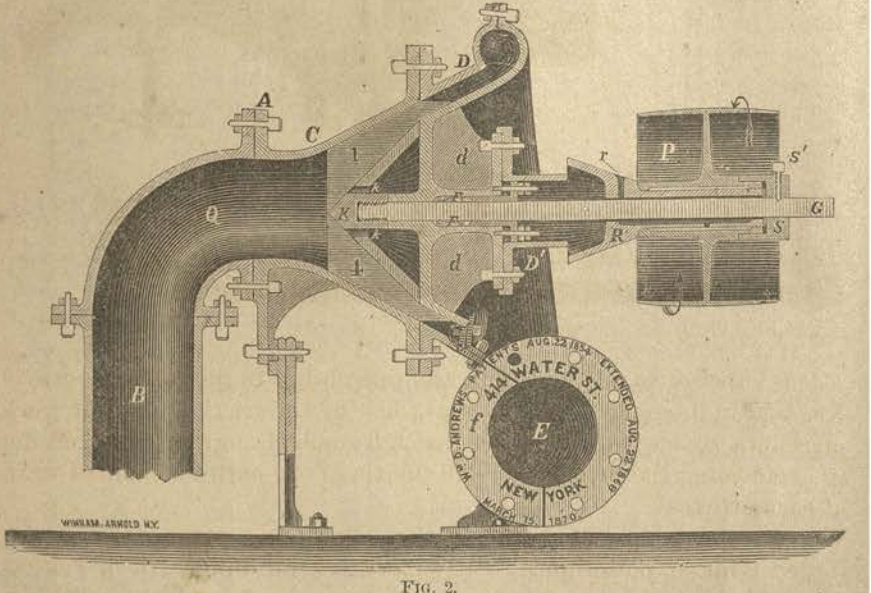


FIG. 2.

disk K extend above the disk to exclude dirt from the bearings and partially relieve the downward pressure upon the disk. The spaces above and below the disk are connected by holes, *k k*, through the disk, equaliz-

ing the vacuum therein, relieving it from all downward pressure and perfectly balancing it, so that no lower bearing or step is required. The same result is also obtained by connecting the spaces through a pipe passing around the disk outside the pump or through passages cast in its shell.

The advantages claimed are the following:

Having no tight working joints, it is almost frictionless, and having no working valves or other loose parts to get out of order, it will run for years without repairs, and pump large quantities of mud, sand, gravel, coal, grain, paper-pulp, tan bark, meal, beer, molasses, oil, &c., without injury or derangement. It saves from 40 to 60 per cent. of the power used by others and works equally well as a suction or force pump.

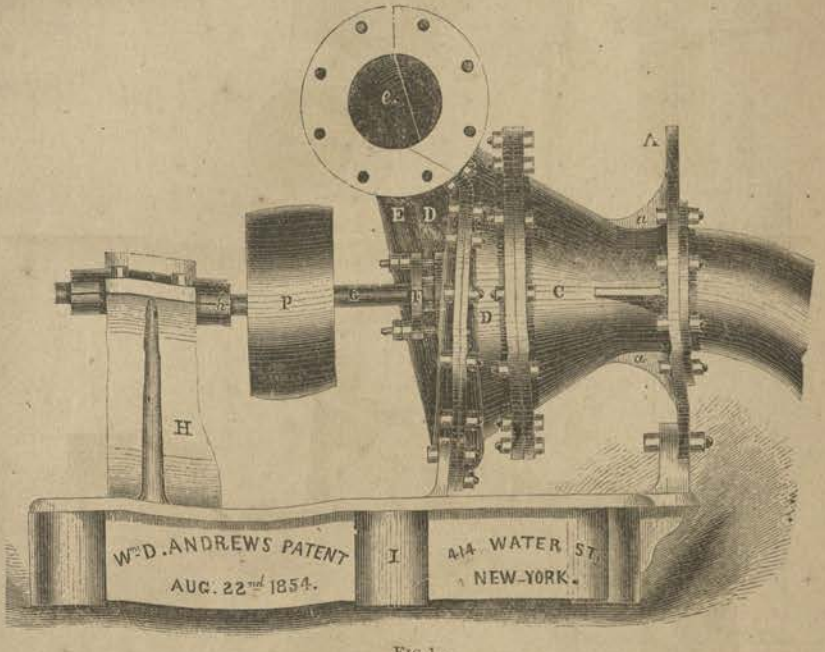


FIG 1.

It is superior to piston pumps from its ability to pump sand, gravel, &c., and in its great saving of power lost by the friction of tight working joints, by moving the water through crooked angular passages, and in overcoming the momentum and inertia of the entire column of water at each stroke.

Over other centrifugal pumps the advantages claimed are a very large saving of power and greatly increased durability; it moves the water through easy curved passages instead of at angles, and dispenses with a step or other downward bearing, avoiding the great downward pressure and wear usually imposed thereon, and gives an unobstructed inflow. The several parts are experimentally proportioned, the

surfaces turned and finished, and the disk balanced, enabling it to work with maximum efficiency and economy.

The same firm makes engines, double and single, to couple direct to

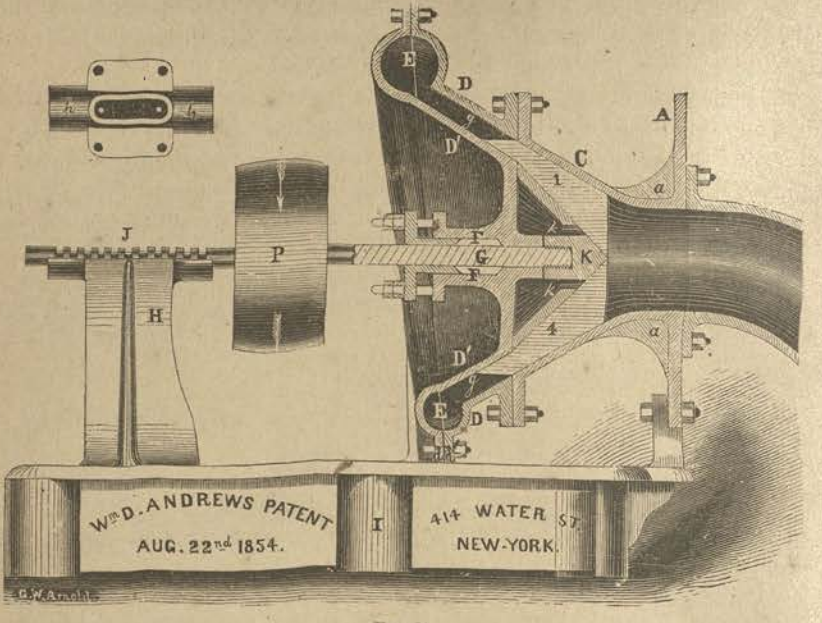


FIG. 2.

the shafts, without belting or gearing, for driving the sizes from No. 6 upwards, to raise water from 20 to 30 feet high.

FIG. 3.

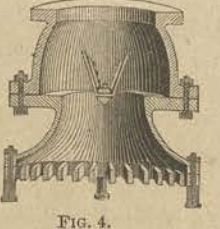


FIG. 4.

Pumps with these engines attached are extensively used for surface condensers, draining and irrigating lands, dry-docks, coffer-dams, gold-washing, wrecking, &c.

HEALD AND SISCO CENTRIFUGAL PUMP, BALDWINSVILLE, N. Y.

THE HOLLOW-ARM WHEEL.

Figs. 1 and 2 exhibit different styles of the piston wheel of this pump. The hollow-arm piston shown above is the one on which the frame of

the pump is mainly based, and is adapted for raising water or any thin fluid not too much encumbered with stringy or tenacious material.

The chamber C communicates directly with the space outside the pump, the raised wall or rim being turned on its outer circumference to fit the opening in the shell. The fluid to be raised flows or is drawn

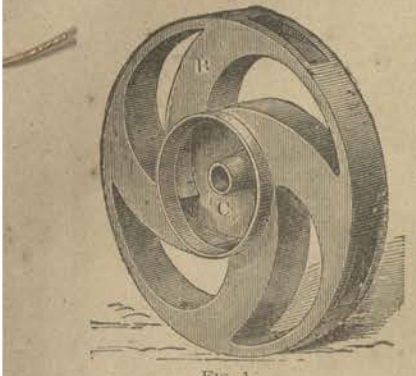


FIG. 1.

FIG. 2.

into this chamber, and is expelled by the rotary motion of the wheel through the hollow arms, escaping through the opening in the rim. Between the outer face of the wheel and the walls of the shell there is a space which gradually widens as the current approaches the place of exit from the pump until it attains the full dimensions of the discharge pipe. The water being confined in the space beyond the wheel is not thrashed about by the arms, but is forced steadily forward into the discharge pipe.

THE CONCAVE-ARM WHEEL.

The "concave-arm" pump, of which Fig. 2 shows the piston wheel, is used for essentially the same purposes as the "hollow arm" variety, and is not far behind that style in effectiveness. The prices are the same as for corresponding sizes of the hollow-arm pump.

THE "NEW" CONCAVE-ARM PUMP.

This style is designed expressly for raising "half-stuff" in paper mills and the stringy material sometimes found in the liquors of tanneries. Its external appearance is the same as that of the hollow-arm pump, but the wheel has broad "concave" arms, which do not taper, and is adapted to this difficult work, or to any other for which centrifugal pumps are ever used.

THE VERTICAL PUMP.

Fig. 3 is a representation of the "vertical" pump, originally so named on account of the shaft being perpendicular. The scroll or shell A is of brass or cast-iron, as circumstances require, made in halves, and bolted together in the usual manner. The piston (Fig. 1), already de-

scribed, is attached to the shaft D, and works in the scroll, running lightly, in nicely fitting bearings. The fluid enters the pump at the bottom, and is discharged at F.

The vertical pump is intended to stand on the bottom of the junk,

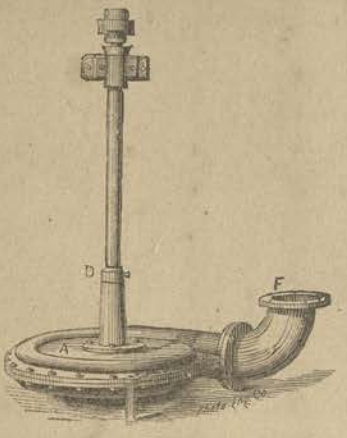
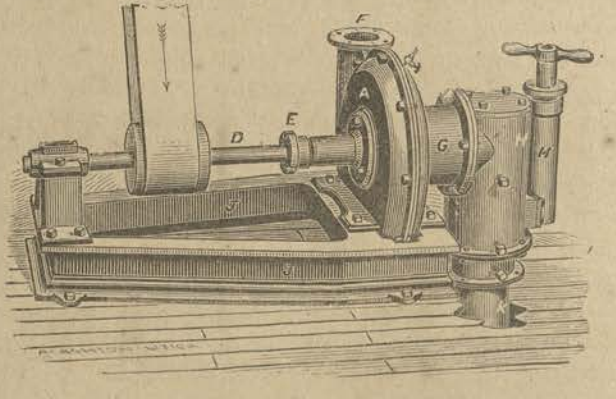


FIG. 3.

tub, well, or reservoir, as the case may be, or it can be fastened at any required distance from the bottom; the only essential point being that the pump should be constantly immersed in the fluid to be raised.

For draining lockpits, coffer-dams, tan-vats, &c., in short, for any situation in which large quantites of very foul water, containing mud, sand, gravel, bark, &c., are to be raised expeditiously and cheaply the vertical pump is well adapted.



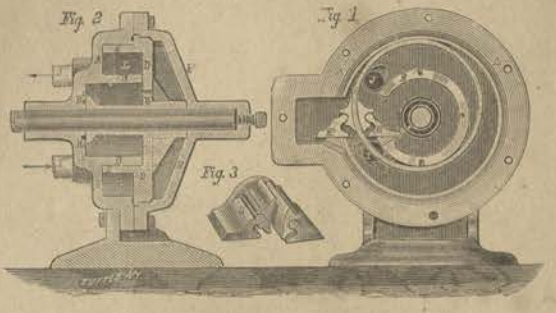
THE HORIZONTAL PUMP

is filled with either the hollow or concave-arm wheel according to the work for which it is required. It is furnished with an attachment for charging itself, and may be used in similar localities to other centrifugal pumps.

BAGLEY & SEWALL'S ROTARY FORCE PUMP, WATERTOWN, N. Y.

The illustration presents sectional views of this newly-invented rotary pump.

An examination of the drawing will demonstrate that it is absolutely positive as a suction and force pump.



Advantages claimed.—The entire capacity of the cylinder is utilized, both compartments, outside and inside the eccentric ring, being filled and emptied at each revolution, whether the speed be fast or slow.

Every joint is of metal and self-packing, avoiding stuffing boxes and packing. It has no valve, and the working parts are exactly balanced in the water, equalizing the pressure on all portions. It delivers a steady stream, forcing the same to any desired height, without leakage, and at any desired speed; the volume of water discharged, under all conditions, being exactly proportionate to the power and speed applied, enabling any given amount of work to be done, without the expenditure of any surplus power.

Fig. 1 is a vertical longitudinal, and Fig. 2 is a transverse section.

A is the main case or body of the pump in one piece, on the interior of which is the ring B, the space outside of B being the cylinder or water space. This cylinder is inclosed by the disk D, which is attached firmly to the shaft. To the disk D is attached eccentrically a ring, E, a portion of which is always in contact with the outside of casing A, and also with the ring B, at a point exactly opposite, so that the eccentric ring E is really the piston of the pump; the disk and ring being rotated by the shaft driven by pulleys of proper size. I is the suction port and J the discharge. These ports are separated by the sliding abutment H, which moves back and forth on its seat with the throw of the eccentric ring E. The tumblers fitted to this abutment adjust themselves to the ring, and as the pressure is constant upon them from above, they effectually pack the ring and prevent any escape of water below.

The water enters at I, and as the piston ring rotates, it is forced before and between it and the casing, around to the upper portion of the latter and out at the port J. As the ring rotates, it opens a space between its inner periphery and the fixed ring B, into which space the

water from port I enters, filling the interior of the piston, to be forced out as before. The center ring B is made enough deeper than the casing A to exactly equalize the contents of the inside and outside of the piston ring E, thus securing a perfectly steady flow of water from the discharge. F is the cover or outside case. Holes are made through the disk D, to allow the water to pass through and between it and the outer case, thereby balancing the working parts, and equalizing the pressure upon them. One end of the shaft has a closed bearing in the outer case; the other bearing is in the case A. On the shaft, and being a part of the disk D, is a collar which is fitted to the seat K, making a perfect water tight joint, by which all "packing" of the pump is avoided. In the center of the seat K is a circular groove, which connects by a drilled channel with the suction port. Should there be any tendency to escape of water at the seat K, the force of the suction keeps the port closely to the seat, and absolutely sealed against air or water.

All parts are made to exact gauges, and are interchangeable. In case repairs or examination of the pump is necessary, by removing the outer case, the working parts are all exposed, without breaking connections of any of the pipes. Having no valves, it is able to *pump anything* sufficiently liquid to pass through the pipes.

ROTARY LIFT AND FORCE PUMP.

Made by W. & B. Douglas, Middletown, Conn.

The advantage claimed for this pump is in effectually overcoming the objections which have heretofore been experienced in the use of other rotary pumps, viz, the great friction and consequent wear to the working parts when under any considerable head and the difficulty of keeping the pump perfectly packed, and of otherwise repairing the same. This is accomplished as follows:

First. There are passages made through the slides or valves from front to back (see Fig. E), which permit these valves to work in and out of the chambers in which they move, without hydrostatic resistance, as the pressure of the water upon the back and front edges of the valves is balanced, this pressure being rendered the same within the chambers as without by the passage-ways through the valves; also, the movements of the valves in their chambers do not take place when they are doing their work, but, on the contrary, they move only when the pressure of the water is equal on all their sides; they will, therefore, slide in and out of their chambers so easily that their own weight will effect these movements, unless the pump should be run at so great a speed that the centrifugal force would overcome that of gravity. The pins on the ends of the valves thus work with the smallest possible amount of friction in the grooves which determine their movements. This will be readily understood by reference to the sectional view of pump, shown by Fig. D..

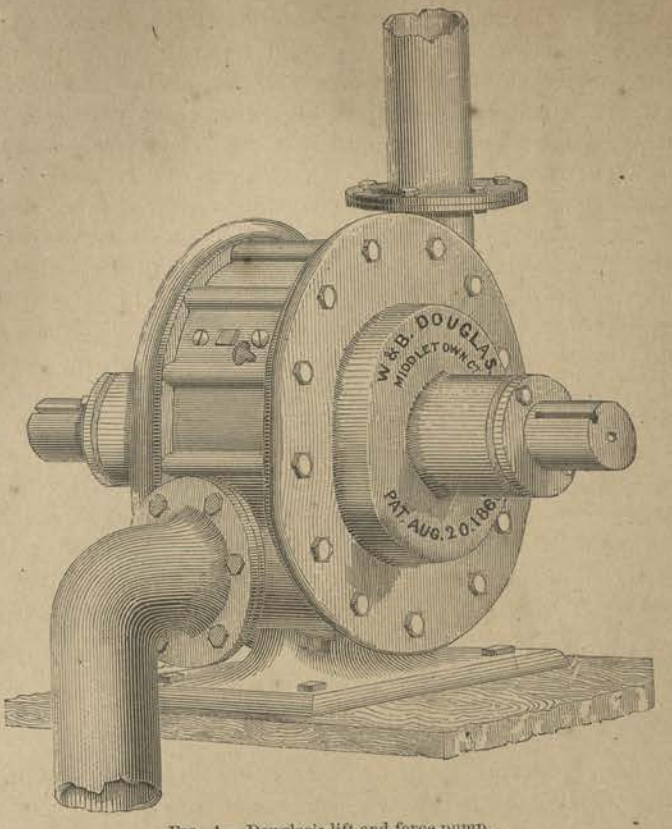
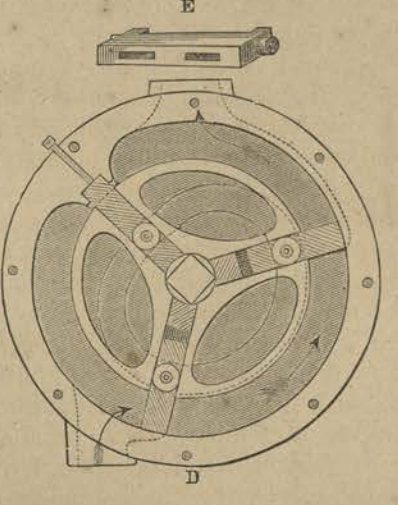


FIG. A.—Douglas's lift and force pump.



All sizes are in successful operation, ranging from a small barrel pump, for pumping water, oil, or spirits, to a water-works pump, supplying over 20,000 gallons per hour to a reservoir nearly a mile distant, the pump sustaining a pressure of 55 pounds to the square inch with a suction of about 10 feet. Many of the smaller pumps are in use, where they lift the water from 20 to 24 feet.

Prices of Fig. A, with pulleys on same.

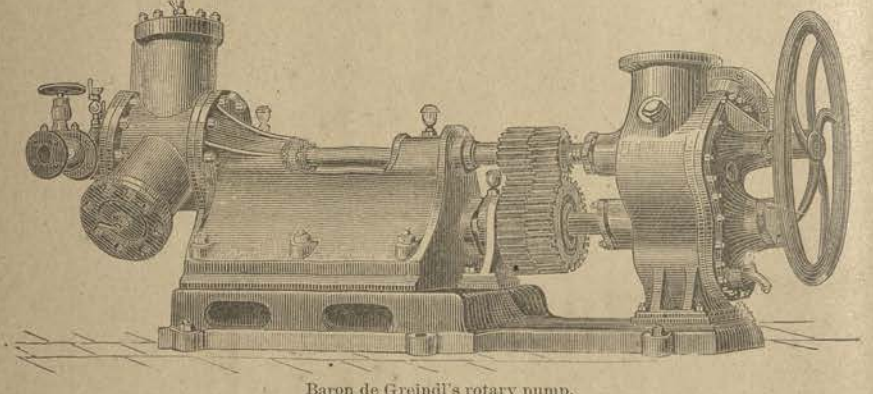
Size.	Style.	Material.	Number of revolutions per minute.	Number of gallons per revolution.	Size of pipe.	Price.	Price with bed and shaft for pulley.
					Inches.		
12½ inches.....	Fig. A....	Iron	20 to 100	13-10	2½	$150	$195
16 inches.....	Fig. A....	do	20 to 90	3½	4	250	295

Pulleys included in the above prices.

BARON DE GREINDL'S PATENT ROTARY PUMP.

Constructed by Leon Moreau, Brussels, Belgium.

Peculiarities claimed.—It is not a centrifugal but in reality a true lift and force pump, having a continuous piston motion, and will raise water to any height, giving a high percentage of efficiency.

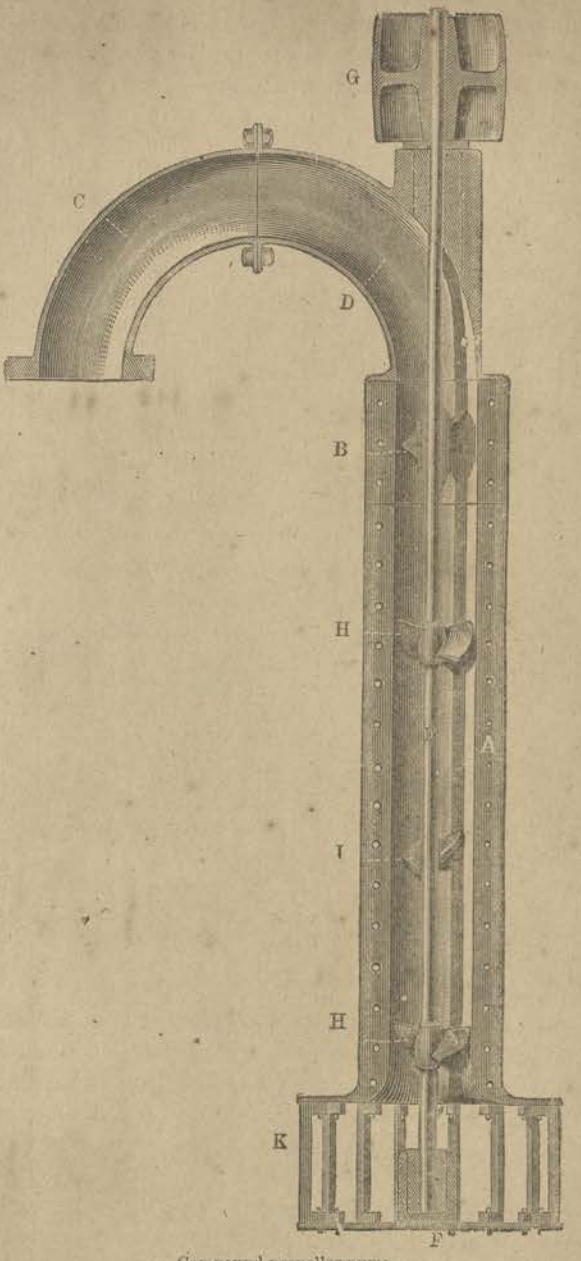


Baron de Greindl's rotary pump.

It is always ready for starting, never requiring preliminary filling with water; lifting and forcing are regular and continuous; no jerking or jarring; no valve springs or internal parts possessing intermittent motion; water flows at a constant speed through the body of the pump; the lifting power is a practical maximum; will pump any fluids; speed of the pump is remarkably slow; it ought not to exceed 150 revolutions per minute for an outflow of 120 gallons, nor 950 revolutions for a delivery of 1,500 gallons to *any height;* no air chamber is needed; the useful effect of this pump, working at moderate heights, is between 75 and 80 per cent. The waste increases very slowly, the ratio being as the square root of the height.

COMPOUND PROPELLER PUMP.

Made by Hydrostatic and Hydraulic Company, 915 Ridge avenue, Philadelphia, Pa.



Compound propeller pump.

The pump consists of plain cast-iron pipe A, provided at bottom with basket-chamber K and at top with elbow D, and has inserted in cen-

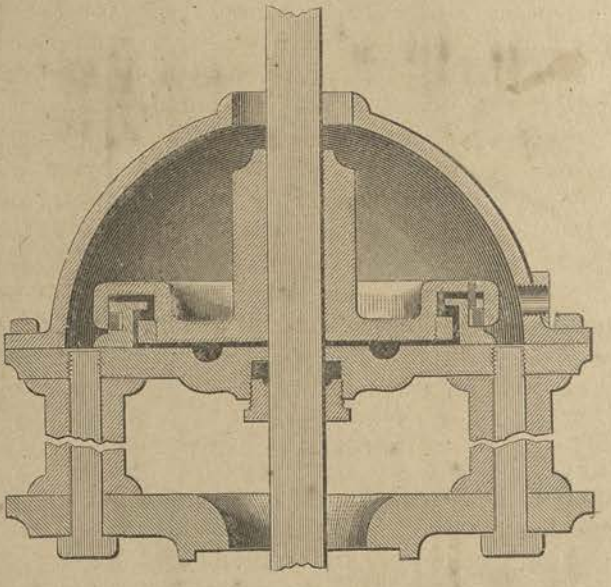
ter of pipe A a propeller shaft, F, carrying propellers H H; intervening which are stationary wings, I, and every 5 feet a bearing, B, is provided. The shaft runs in journal in top of elbow D, and is propelled by belt on pulley C from any source of power.

This method of constructing pumps reduces the parts to the least number possible; consisting only of two parts, the pipe with the propeller shaft inserted thus—having only one moving part, with no valves or other complications to clog up or get out of order.

The large sizes are provided with a water-bearing to support weight of shaft, &c., in a frictionless manner.

These pumps are of compact construction. The small pump throws 1,000 gallons per minute.

This pump can be driven by belt or engines direct to propeller-shaft;



dirt and rubbish can be pumped when mixed with water. The pump fills itself with water and does not have to be started by pouring water into the same as in centrifugal and many other pumps.

The advantages claimed are:

1st. Simplicity of construction, having no valves, and consisting of but three pieces—the column-pipe, shaft, and propeller.

2d. Economy; costing much less than any other pump of the same power.

3d. Enormous power; a 7-inch pump yielding 1,000 gallons per minute; an 8-inch, 1,200 gallons; a 10-inch, 2,000 gallons; and a 20-inch, 10,000 gallons per minute. A 6-foot pump throws the enormous quantity of 100,000 gallons per minute!

4th. Adaptation. It can be used either as a force or lift pump, and can be placed vertically, horizontally, or at an angle.

5th. Requires no oiling, and will lift sand, mud, sticks, and other rubbish without any interference with its efficiency.

6th. It will elevate water to any height.

CROSS-SECTION OF WATER-BEARING.

The water-bearing is a device, applied to the compound propeller-pump for sustaining the weight of the column of water with the shaft and propellers. It consists of a cast-iron beam, which rests upon the top elbow of the pump, and upon which are secured pillars supporting a stationary disk, provided with an ordinary stuffing-box, through which revolves the propeller-shaft. Under a dome which rests on the stationary disk is another disk, which is secured to the propeller-shaft and revolves with it, and which is provided with an annular piston, with ring packing. Water is forced by a donkey force-pump between the stationary and revolving disks, through an ordinary pipe, under a pressure equal to the weight to be sustained per square inch, which is confined between these disks by the annular piston, thus separating them by a film of water upon which the revolving disk floats, sustaining the entire weight of the revolving machinery and most of that of the column of water lifted by the pump. Any surplus water forced between the disks tends to lift the revolving disk higher than a given point, and raise the annular piston off the stationary disk and thus allow this excess of water to pass out under it, which is received into the dome and returned through a common pipe to the tank from which it was supplied.

AQUOMETER STEAM-PUMP.

This pump is peculiarly adapted for pumping out mines, wells, &c., and has the advantages of requiring no foundation and no special care; it will pump sand, mud, sawdust, and the like.

In excavating shafts it can be hung by chains or ropes and raised or lowered at will as the work progresses.

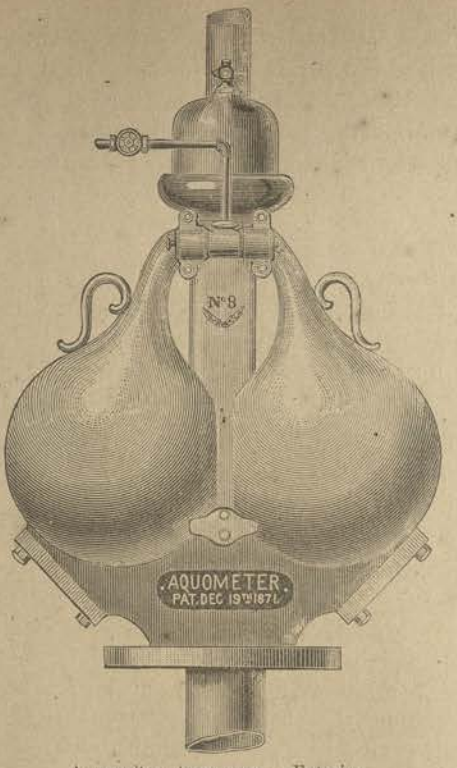
It acts by the steam first exerting a direct pressure and forcing the water out of the pump, and then condensing, forming a vacuum, and thus lifting the water into the pump for the next stroke; its action is similar to that of the pulsometer, which see.

Furnished by the American Dredging Company, Philadelphia.

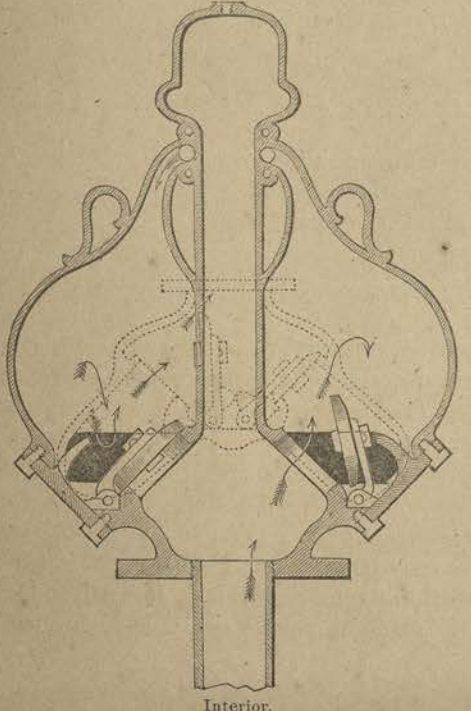
THE PULSOMETER STEAM-PUMP.

Manufactured by Pulsometer Iron Works, Jersey City, N. J., J. A. Grosvenor, agent.

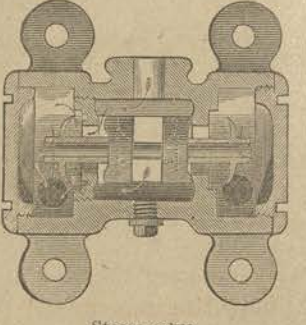
The illustration represents in section the latest form of the "Pulsometer," which in design and construction is claimed to combine durability,



Aquometer steam-pump.—Exterior.

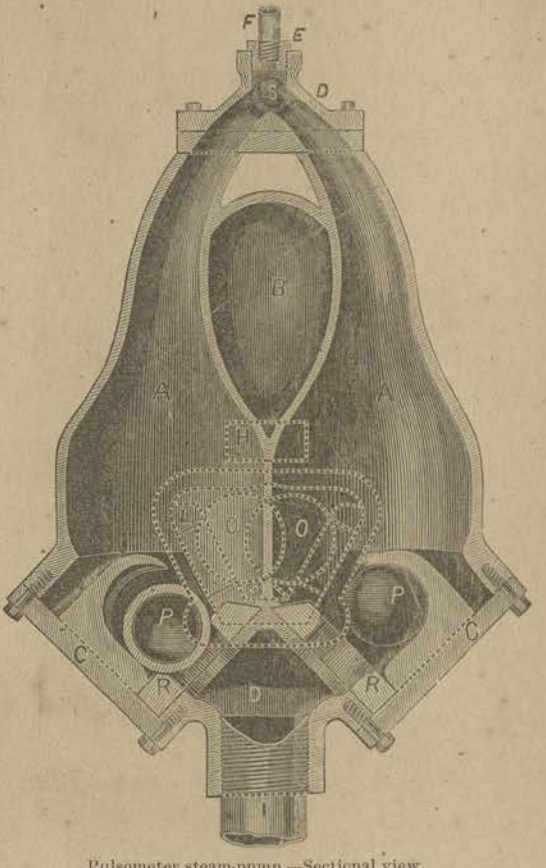


Interior.



Steam valve.

efficiency, simplicity, and strength. Its operation is sustained by steam pressure brought to bear directly upon the liquid as the forcing element, while the subsequent condensation of the same furnishes the lifting force to supply the pump, which action is maintained by the purely functional conditions of alternate pressure and vacuum. The



Pulsometer steam-pump.—Sectional view.

pulsometer, in form and construction, consists principally of two bottle-shaped chambers, A A, joined side by side with tapering necks bent toward each other, to which is attached by means of a flange joint (as shown in the figure) a continuous passage from each cylinder leading to one common upright passage, into which a small ball, S, is fitted so as to oscillate with a slight rolling motion between seats formed in the junction. These chambers also connect with a vertical induction passage, D, which openings are so formed that valves P P, and their seats R R, which may be of any form and material desired, may easily be inserted. The delivery passage H, which is common to both chambers,

is also so constructed that in the opening that communicates with each cylinder can be placed valve seats, L, of any material, fitted either for a spherical shell or ball valve, O O, or hinge valves of metal, wood, or rubber faced, or with any other style of valve and seat that may be desired. B represents the vacuum chamber, cast between the necks of chambers A A, and connects only with the induction passage below the valves P P. C C represent flanges, covering the several openings, to facilitate the removal of valves and seats when necessary. There is also a small air check-valve secured into the neck of each of the chambers A A, and one in the vacuum chamber B, so that their stems hang downward. Vent plugs are inserted into the flanges C C, for the purpose of drawing off the water to prevent freezing.

The operation of the pulsometer is as follows: Connect the steam and water-pipes, place a check-valve on the suction-pipe, fill the suction-pipes and chambers with water, and the pulsometer is ready to operate. Then, if steam be admitted at the top it will pass into whichever chamber the position of the ball permits, and as it enters the chamber directly above the water, it presses upon and forces it out past the discharge-valve through the discharge-pipe with a force equal to the pressure of steam in the boiler. When a ball-valve is used in the discharge-chamber it oscillates between the seats in a manner similar to the steam-ball, and simply checks the back flow of the water after it has been expelled from each chamber. When other styles of valves are used one is placed at the opening from each chamber, so that each will operate as checks. The intermediate chamber B is supplied with air by means of the air-valve, which serves to cushion the ramming action of the water as it rushes into each chamber alternately.

The air-valve in the neck of each chamber allows a small quantity of air to enter above the water, to prevent the steam from agitating it on its first entrance, and thus forms an air-piston, preventing condensation. The quantity of air admitted may be regulated by the milled nut on the stem of each valve.

Price-list of regular sizes.

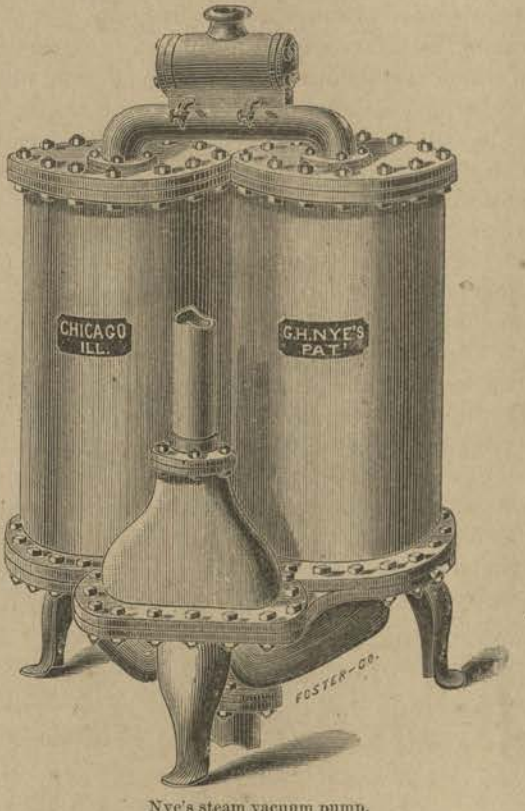
No.	Diameter of each working cylinder.	Height of pulsometer.	Space occupied.	Size of steam supply pipe.	Size of suction-pipe.	Size of discharge-pipe.	Gallons per minute.	Weight.	Price.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*		*Pounds.*	
0	2	6⅔	6½ by 3	⅜	½	½	4	5	$25 00
1	3	10	6½ by 4	⅜	1	1	8	10	50 00
2	4½	15	9½ by 6	½	1½	1½	20	24	100 00
3	6	19	12½ by 8	⅝	2	2	60	60	150 00
4	7½	24	16 by 10	¾	2½	2½	110	114	200 00
5	9	30	19 by 11½	⅞	3	3	175	175	250 00
6	10½	35	22 by 13	1	3½	3½	300	275	300 00
7	12	40	25 by 15	1¼	4	4	425	375	400 00
8	15	50	31½ by 20	1	5	5	750	500	600 00
9	18	60	37½ by 24	1¼	6	6	1,100	800	800 00
10	21	70	45 by 28	1½	7	7	1,500	1,200	1,100 00
11	24	80	50 by 30	2	8	8	2,150	1,760	1,500 00

NYE'S STEAM VACUUM PUMP.

Nye & Palmer, manufacturers, 75 West Washington street, Chicago, Ill.

This pump operates on the same principle as the aquometer and pulsometer steam pumps elsewhere described.

By referring to the cut it is seen that the machine consists of two cast-iron cylinders, lined with wood to prevent loss of steam by contact with the metallic surfaces. The condenser (a plain chamber back of cylinders) a simple, balanced, automatic steam valve (seen on top of cylinders) and four common clack-valves, covering suction and delivery ports. The whole is supported on a raised base.



Nye's steam vacuum pump.

When the pump is set in position and the ordinary connections of steam, suction, and discharge pipes have been made, the condenser is to be filled with water, and the pump is now ready to start. Steam is then admitted to one of the cylinders for an instant, dispelling the air, and is then turned off. This steam is immediately condensed by a spray or jet of water passing into the bottom of the cylinder by means of a passage from the condenser, thereby forming a vacuum, which allows the atmosphere to force water through the suction-pipe, filling the cyl-

inder from below. The effect of the vacuum has also been conveyed at the same instant by a port from the steam passage to one end of the sensitively balanced steam valve, causing it to move gently towards the vacuum, shutting the steam ports to that cylinder and opening those to the other. Steam is again turned on, and entering the second water cylinder the same operation is repeated as in the first, the vacuum is formed, the valve shifts, and the cylinder is filled. We have now two cylinders of water, and the steam ports to the first cylinder are open. Steam is now finally turned on and the globe valve regulated for the amount of steam necessary to do work. One pound pressure being needed for every 2 feet of elevation. The steam enters the cylinder, and acting directly upon the water, forces it out through the discharge-pipe, a small quantity at the same time enters by a passage in base of pump in the condenser, compressing the air at top of water, and forming an air-cushion. At the instant the cylinder is emptied the pressure on the air-cushion is relieved (in consequence of an attempt of the steam to follow the water of the discharge-pipe), and the rebounding of the air-cushion forces a jet of water back into the cylinder full of steam, condensing it instantly, and forming a nearly perfect vacuum, thus utilizing the steam which is ordinarily the exhaust. Thus the vacuum is formed, the cylinders filled, and the steam-valve operated at *no expense of live steam* or loss of power.

The port to the second cylinder now being open, the steam discharges the water from that while the first is filling. The action is then repeated on each cylinder alternately. The pump will run with but little attention, pumping the most impure water that is required of any pump to raise.

Price-list of regular sizes.

[Revised February 1, 1876.]

No.	Horse-power of boiler needed to pump to full capacity.	Capacity in gallons of each cylinder.	Size of steam-pipe.	Size of suction-pipe.	Size of discharge-pipe	Gallons per minute at an elevation of—				Price.
						20 feet.	50 feet.	100 feet.	150 feet.	
			Inches.	*Inches.*	*Inches.*					
0	2	½	¾	1	¾	15	.....	.....	.....	$65
1	3	1	¾	1½	1¼	35	.....	.....	.....	100
2	5	2½	¾	2	1½	100	75	60	40	150
3	8	5	¾	3	2½	175	115	75	50	200
4	10	8	1	4	3	300	200	140	100	250
5	12	15	1¼	5	4	500	400	300	200	350
6	15	25	1½	6	5	800	700	600	400	500
7	20	50	2	8	7	2,000	1,600	1,000	600	800
8	35	75	2	9	8	2,500	2,000	1,200	800	1,000
9	50	100	2½	10	9	3,000	.....	.....	.....	1,200
1	80	200	3	12	10	5,000	.....	.....	.....	2,000

ROCK-DRILLS.

Among mechanical appliances useful to the engineer rock-drills stand in the foremost rank. Without them such works as the Hoosac Tunnel, tunnels of St. Gotthard and Mont Cenis, and, of a more recent date, the work at Hallet's Point (Hell Gate), New York, could not be carried to a successful conclusion without an immense expenditure of time and money.

Nearly all the drills on exhibition have points of excellence, and as the subject is so important I have omitted but few. I do not pretend to give any particular one the preference, merely setting forth the advantages *claimed* by each patentee or manufacturer.

BURLEIGH ROCK-DRILL COMPANY, FITCHBURG, MASS.

The following description of this drill is condensed from the pamphlet issued by the company.

Main elements of the drill are the cage, the cylinder, and piston. The cage is merely a trough, with ways on either side, in which the cylinder, by means of a feed-screw and automatic feed-lever, is moved forward as the drill cuts away the rock.

The piston moves back and forth in the cylinder, propelled and operated either by steam or compressed air.

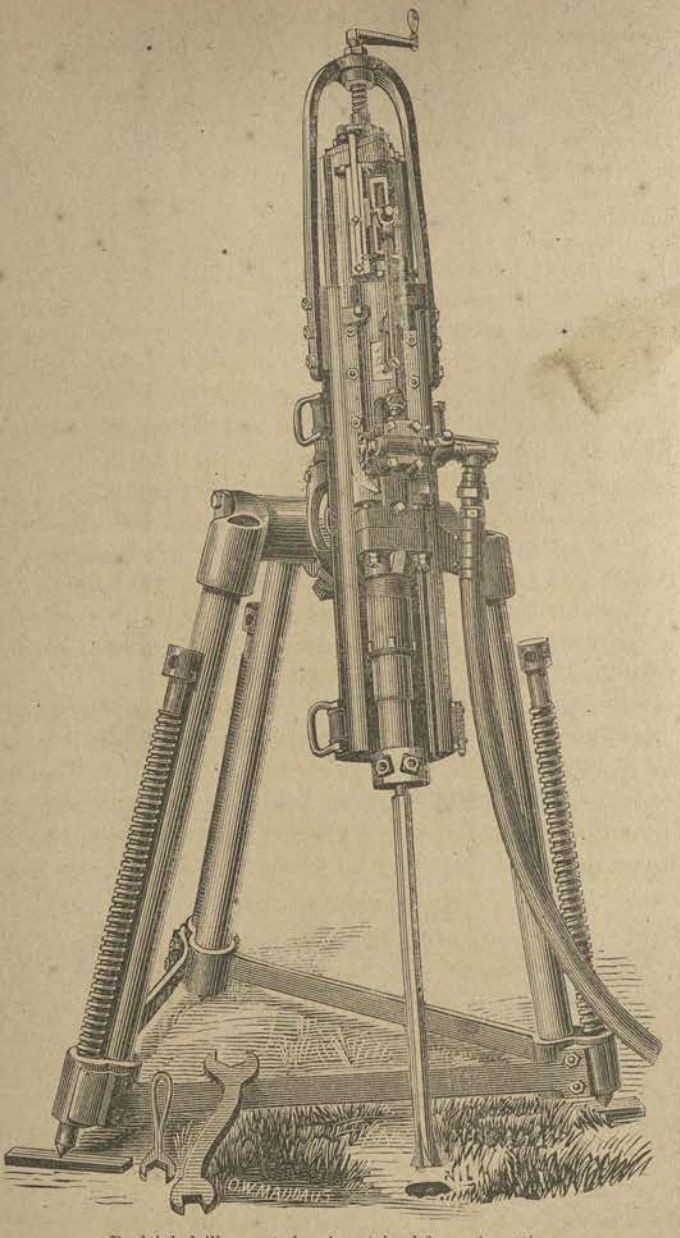
The drill-point is attached to the end of the piston, which is a solid bar of steel. The piston is rotated as it moves back and forth by a single mechanism. The forward motion of the cylinder in the trough is regulated by an automatic feed, the advance being more or less rapid in proportion as the cutting is fast or slow. It will thus be seen that the drill-point and solid steel piston alone receive the shock of the blow. When the cylinder has been fed forward the entire length of the screw feed it may be run back, and a longer drill-point inserted in the end of the piston.

The regular rotation of the drill insures the delivery of each blow at the point of greatest efficiency, each wing of the drill-point striking the rock at a point just far enough in advance of the cut of the preceding blow to chip away the rock lying between.

The yielding of the chip saves the edge of the drill-point, and thus the advance of the drill-point in the rock, without sharpening, is *ten times greater* than is possible in hand-drilling, where the hole is formed by the crushing and pulverizing of the rock.

The drill is so mounted that it can be pointed in any direction, different styles of drills having different mountings.

These machines are applicable to all kinds of rock work, whether mining, quarrying, cutting, tunneling, or submarine drilling. Holes may be drilled from $\frac{3}{4}$ inch to 5 inches diameter to a depth not exceeding 30 to 35 feet, at the rate of from 2 to 10 inches per minute, according to the nature of the rock. They are driven by steam or compressed air, and, at a pressure of 50 pounds to the inch, work at 200 to 300 blows per minute, according to the size of the machine.



Burleigh drill mounted on iron tripod for rock-cutting.

PRICE-LIST.

DRILLS.

Stoping drill	$550 00
Mining drill	600 00
Mining drill, improved pattern	650 00
Tunnel drill	675 00
Sewer drill	950 00
Heavy sewer drill	1,200 00

DRILL CARRIAGES.

New York pattern (long bar)	$130 00
Iron tripod for large drill	150 00
Iron tripod for jumper	75 00
Mining carriage	300 00
Mining carriage, with side-bars	265 00
Column for small drifts	110 00
Large tunnel carriage	1,600 00
Small tunnel carriage	
Drill clamps, 6 inches	30 00
Drill clamps, 4¾ inches	20 00
Drill points, finished, per pound	30

Stoping drill drills 1¼ to 1¾ inch holes, and feeds 20 inches without changing drill-points. Extreme length, 3 feet 2 inches; extreme size on cross-section, 9 by 10 inches. Weight, 206 pounds.

Mining drill drills 1¼ to 2 inch holes, and feeds 26 inches without change of drill-points. Extreme length, 4 feet 7 inches; extreme size on cross-section, 13 by 9½ inches. Weight, 475 pounds.

Improved mining drill drills 1¼ to 2 inch holes, and feeds 24 inches without change of drill-points. Extreme length, 3 feet 9 inches; extreme size on cross-section, 12 by 10½ inches. Weight, 330 pounds.

Tunnel drill drills 1¼ to 2½ inch holes, and feeds 36 inches without changing drill-points. Extreme length, 5 feet 7 inches; extreme size on cross-section, 13 by 9½ inches. Weight, 550 pounds.

Sewer or submarine drill drills 2 to 4 inch holes, and feeds 44 inches without changing drill-points. Extreme length, 6 feet 8 inches; extreme size on cross-section, 13 by 12 inches. Weight, 675 pounds.

Heavy submarine drill drills 3 to 5 inch holes, and feeds 54 inches without changing drill-points. Extreme length, 8 feet 9 inches; extreme size on cross-section, 15 by 13 inches. Weight, 1,000 pounds.

THE DIAMOND DRILL.

While other drills bore holes in the rock by a succession of blows the diamond bores an annular hole, the core remaining intact. It is this feature which makes it specially valuable for prospecting purposes.

The boring tool is a hollow bit of steel having three rows of diamonds (bort or carbon embedded in it), one row projecting from the face, the others from the outer and inner surfaces respectively.

The drill rod is hollow, and a stream of water is forced through it while drilling.

The following advantages are claimed:

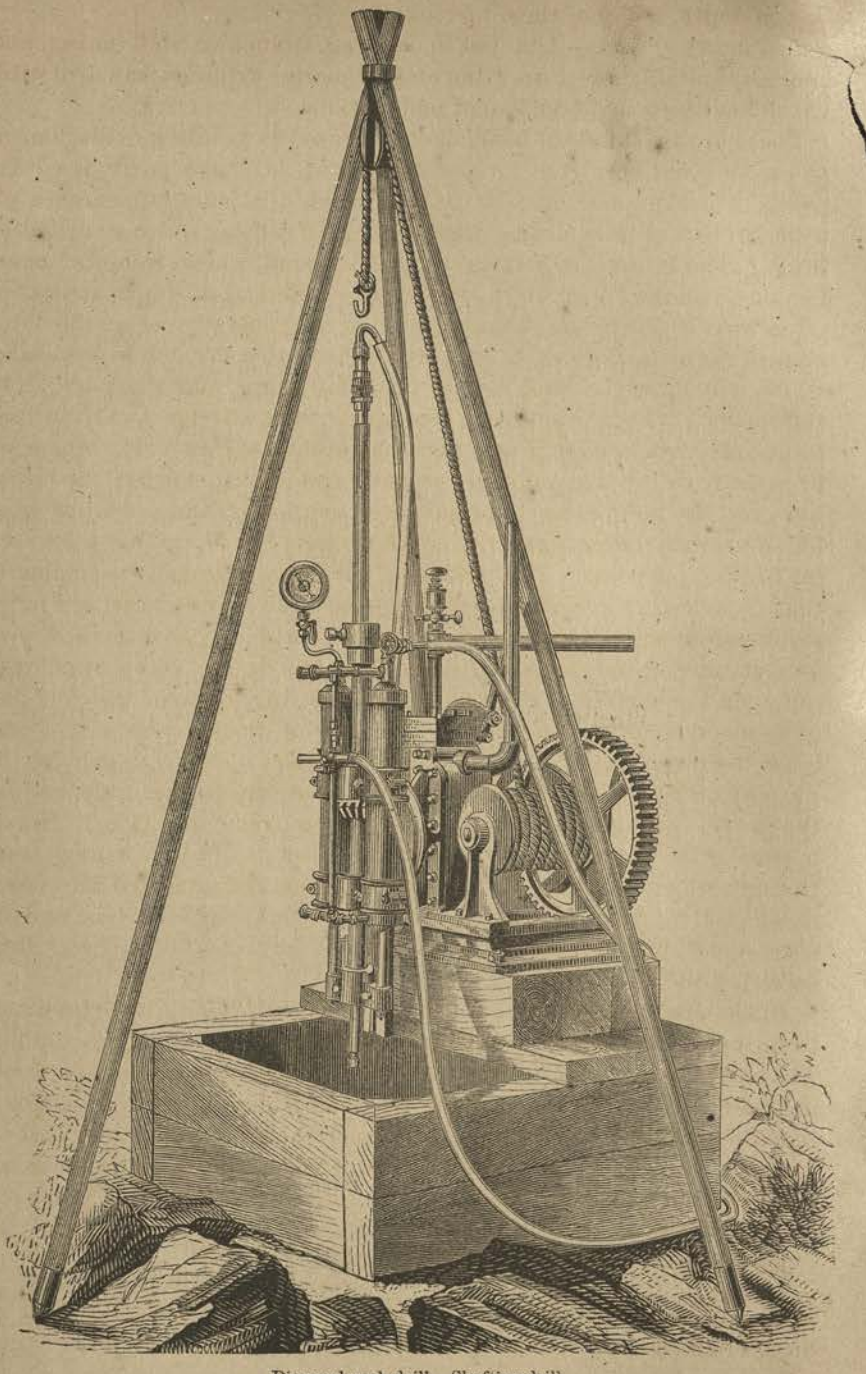
1st. *Speed in boring.*—They drill faster than any other way.

2d. *Economy in using.*—They perform a given amount more cheaply than it can be done otherwise, 33 per cent. cheaper than hand labor.

3d. *Durability and simplicity.*—Simple in construction; seldom need repairs; can be run by workmen of ordinary intelligence.

4th. *Cylindricity of holes.*—They produce holes uniform in diameter.

5. They are not deflected from a right line by seams and crevices, nor impeded in their progress by the hardest rock.



Diamond rock drill.—Shafting drill.

6. *Depth of holes.*—Have bored thousands of holes from 300 to 1,500 feet in depth, many of them horizontal.

7. *Variety of uses.*—Adapted to shafting, tunneling, well-boring, and specially suitable for prospecting and submarine drilling; can drill without difficulty rocks 20 to 30 feet under water.

There are two kinds of black diamonds used in pointing drills, known as carbons and bort; the former resembling in shape small irregular pieces of gravel, and in color having much the same appearance as a small piece of brown, dingy-looking coal, not being quite so bright or black. The latter (the bort) is the real diamond, which, from its imperfections, is unfit for jewelry. It is nearly spherical in shape, and is not often used of larger size than a pea, and is generally set on the outer edge of the drill, as from its form it is not so liable to catch in any seams which may be in the rock as the irregular shape and sharp angles of the carbons. These stones are brought, principally for American use, from Brazil, via London, Paris, and Amsterdam, to New York. Some are brought from Siberia, and more recently from South Africa; the latter, however, are more glassy and have less toughness, and are much more liable to crush under pressure than those from Brazil, and are little used for drilling purposes. The process of collecting diamonds is similar to that of collecting gold in alluvial deposits. The coarse gravel and rolled pebbles derived from the primary and metamorphic rocks form the lowest stratum among the sands and clays of the alluvium. This stratum resting upon the surface of the rock is the repository alike of the gold and of diamonds. It is laid bare in the beds of the streams when these cease to flow in the dry season, or are drawn off by sluices made for the purpose. From these beds, as well as from the excavations in the bottom, the gravel is removed, to be washed when convenient. This, in Brazil, is usually in the rainy season, and the work is done in a long shed, through which a stream of water is conveyed, and admitted into boxes in which the gravel is washed. A negro works in each box, and inspectors are placed to watch the work and prevent the laborers from secreting the diamonds.

Diamonds, as being the hardest of known substances, have been used from the earliest times for cutting other stones, like the onyx, sapphire, &c., and more recently were found to be an efficient instrument for dressing burr-mill millstones, and for fashioning various devices in stone; but it remained for modern engineering science to develop their highest practical value. The first application of diamonds to the miner's art and practical rock-drilling was made in 1863 by Prof. Rudolph Leschot, a civil engineer, resident in Paris, France.

The prices of these drills are as follows:

No. 1. Prospecting machine	$4,000
No. 2. Prospecting machine *	5,000
No. 3. Prospecting drill without boiler	3,250

* This machine bores a hole 2½ inches in diameter, 1,500 feet, taking out a 2-inch core.

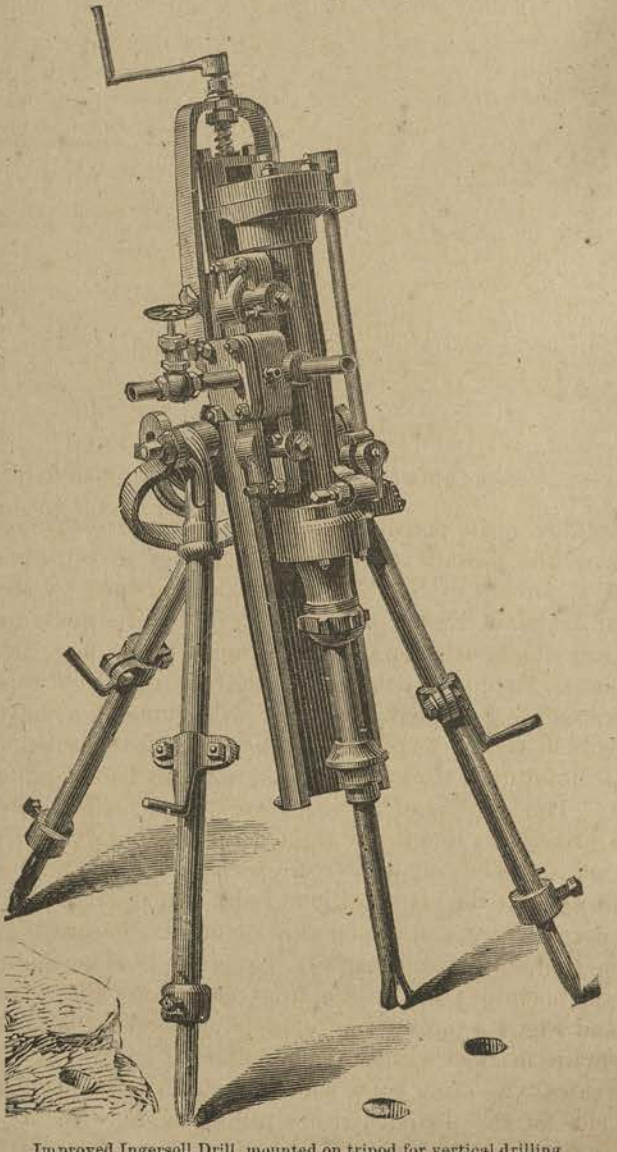
No. 1. Shafting drill, boring 1¾ to 2 inches diameter, 500 feet deep $2,500
No. 2. Tunnel and mining drill, boring 1½ inches diameter, for short hole boring 1,250
No. 1. Open cut and quarry drill, boring 1 to 1¾ inches diameter, 50 feet deep 1,000

American Diamond Rock Boring Company, 37 Weybosset street, Providence, R. I.

Pennsylvania Diamond Drill Company, 110 South Centre street, Pottsville, Pa.

INGERSOLL ROCK DRILL.

Sold by the Ingersoll Rock Drill Company, 1½ Park Place, New York.



Improved Ingersoll Drill, mounted on tripod for vertical drilling.

The following advantages are claimed for this drill:

Durability, simplicity, light weight (one person can handle and carry the drill), adjustability, and the automatic feed, saving the expense of one skilled workman.

It will drill five times as fast as by hand, and at 30 to 50 per cent. less cost. It will drill under water; but success depends upon the construction of an apparatus suited to the particular work.

It has been used successfully at Port Colborne, Canada, at the harbor of Oporto, Portugal, at the River Weaver Navigation Works, England, near Liverpool, and at the Mississippi River improvements, near Saint Paul, Minn.

Particulars of the Ingersoll Rock Drill.

Numbers.	Diameter of cylinders.	Length of piston stroke.	Length of feed.	Depth of hole each machine will bore.	Diameter of hole each is capable of boring.	Average boring done in granite per ten hours.	Average boring in blue syenitic granite, greenstone, and hard trap.	Weight of machine with and without tripod: Machine.	Tripod.	Price of machine, without tripod.	Price of machine with tripod complete.
	Inches.	*Inches.*	*Feet. In.*	*Feet.*	*Inches.*	*Feet.*	*Feet.*				
1	5	6 to 7	2 9	40	3 to 6	70 to 80	30 to 40	558	260	$775	$825
2	4	5 to 6	2 6	20	2 to 4	— to —	— to —	472	245	675	725
3	3½	4 to 5	2 0	12	1½ to 2½	— to —	— to —	295	120	600	650
4	3	3 to 4	1 10	10	1 to 2	— to —	— to —	150	70	500	550
5	2½	3	1 2	8	¾ to 1½	— to —	— to —	88	18	250	250

THE UNION ROCK DRILL.

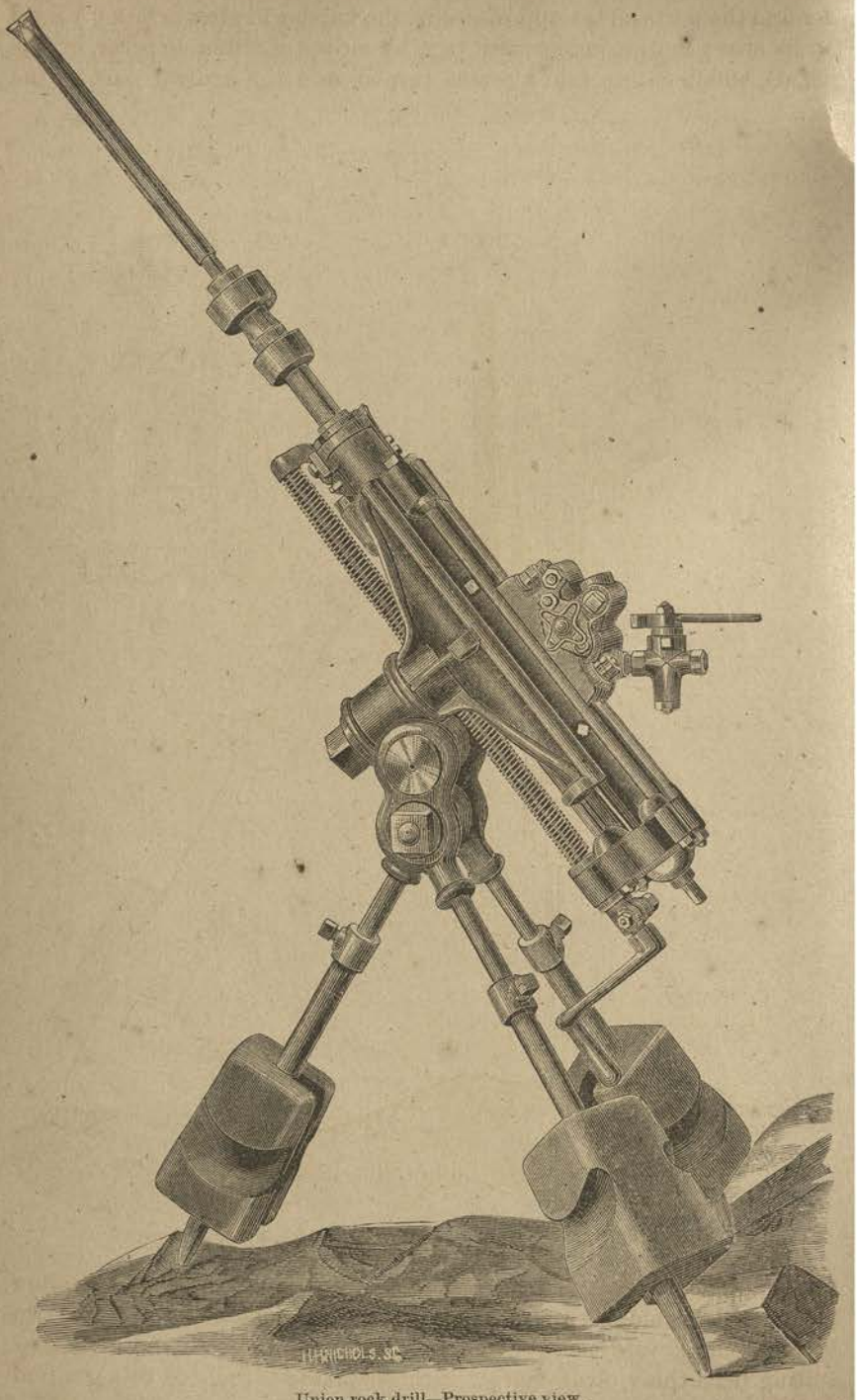
Union Rock Drill Company, 10 Cortlandt street, New York.

This machine, in its present shape, has originated through the consolidation of the patents of E. S. Winchester, of Springfield, Mass., George H. Reynolds, of New York, and those owned by Messrs. C. H. Delamater & Co., of New York. The best features contained in these patents, and which, after long and continued trials, have proved to be most valuable, have been selected for the construction of this new drill. Greatest possible lightness, combined with durability, have been the main objects in view. To obtain lightness steel is the principal material used in the building of the machine, cast-iron only being employed where necessary. The fact of the increased work performed on different kinds of rock is principally due to the rapid running of this drill, a result of the extreme simplicity of its valve, which is moved by the piston directly and without the interposition of any other part.

A perspective view and sectional drawings are herewith given.

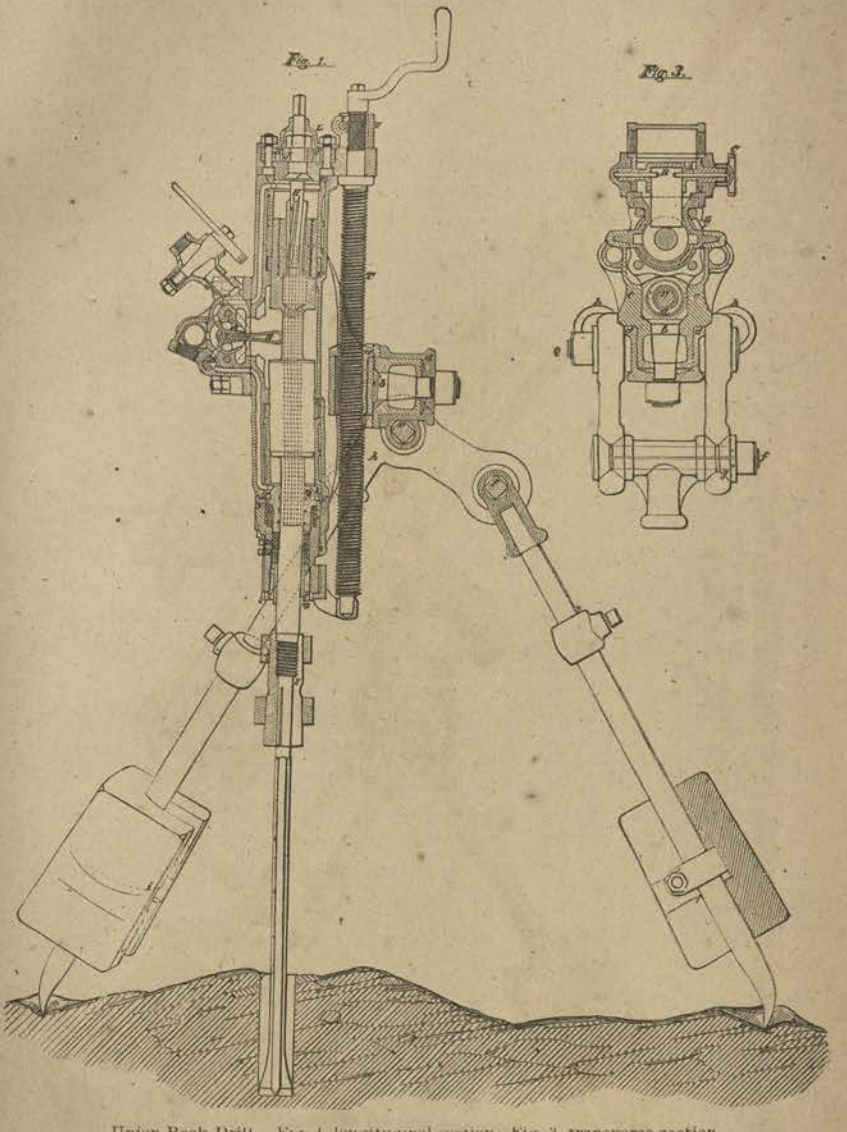
In the accompanying drawing Fig. 1 represents a longitudinal section through the machine; Fig. 2 is a front elevation; Fig. 3 a transverse section, and Fig. 4 a top view of cylinder, showing the rotation. The same parts are marked with the same letters.

1. The *valve.*—A is the valve which regulates the flow of steam or air to either side of the piston. It is a rolling valve, with an oscillatory



Union rock drill—Prospective view.

motion, made of brass. The pressure being on the side towards the cylinder and the ports on the opposite side, the valve will always be kept tight on its seat; motion is imparted to it by means of a double lever, or tappet, B, which enters into a recess turned into the central part of the

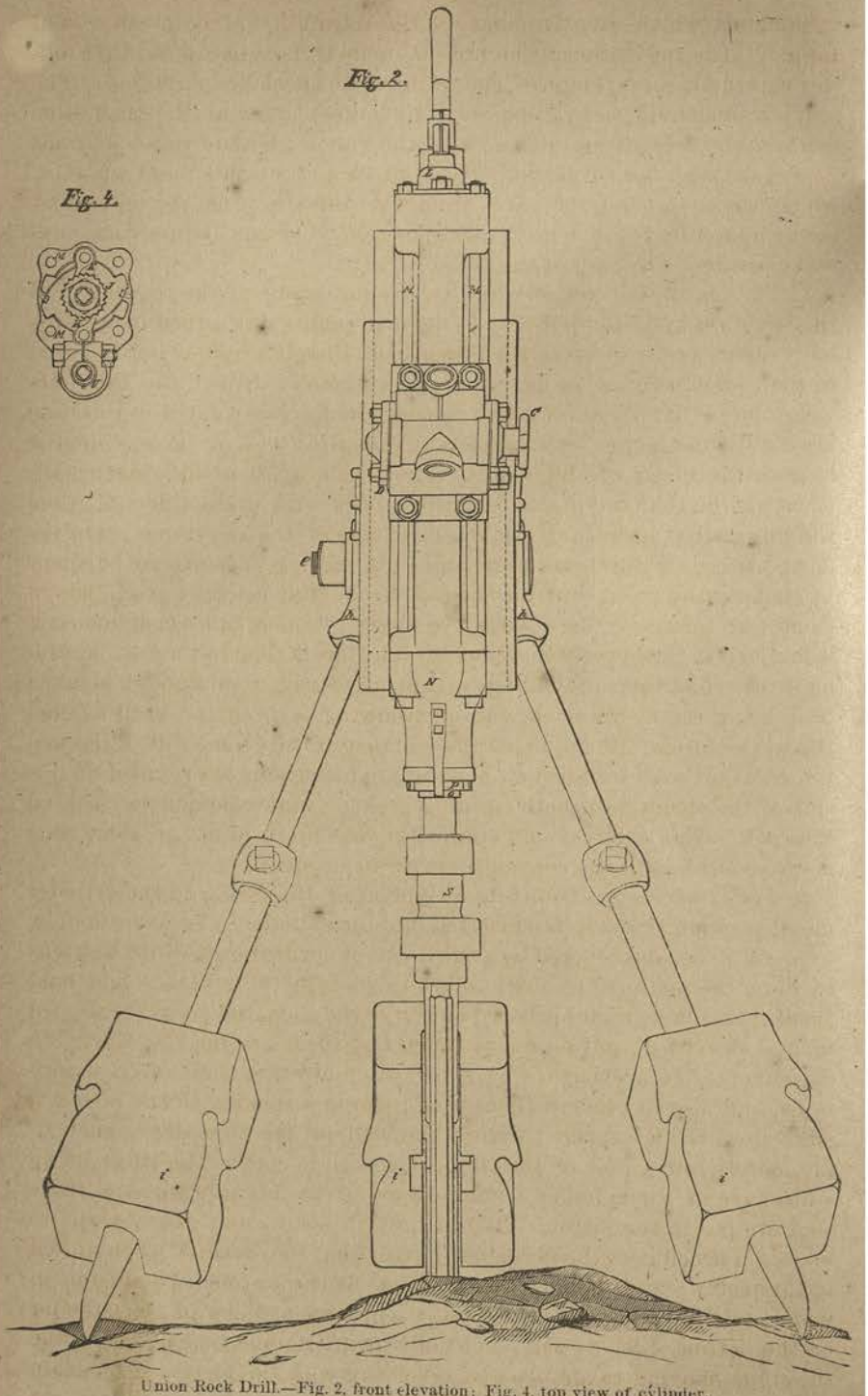


Union Rock Drill.—Fig. 1, longitudinal section; Fig. 3, transverse section.

piston. This lever is made of spring-steel, and sufficiently light to allow for a considerable amount of yielding when the piston strikes it, the two levers coming into successive action. Thus the destructive shock resulting from the violent contact with the piston is reduced to a gradual

Fig. 2.

Fig. 4.



Union Rock Drill.—Fig. 2, front elevation; Fig. 4, top view of cylinder.

cushioning, which greatly enhances the durability of both valve and tappet. The regulation of the flow of steam is the same as in other rolling valves for steam engines, and requires no special explanation. The valve is held from sliding sideways by bonnets, and at the same time receives the central journals cast on the valve. One of these journals passes through the cover and carries at its end a small hand-wheel, *c*, which serves to move the valve from the outside, when the movement of the piston leaves it in its central position, covering both steam-ports and causing a stopping of the drill.

2. The *controlling cock*, marked D, has for its object the regulation of the back stroke of the piston. If the drill points downward it requires more steam or air to bring the piston back than if a hole is being bored in the roof of a tunnel or mine. If a deep hole is drilled the long bits weigh more than the short ones; hence more force is wanted in this case also to lift the longer bits. Different pressures tend in no less degree to alter the speed of the piston. The result of these different conditions will be that the piston is thrown back with great velocity, when the power that propels it is much in excess of the resistance. On the down stroke all the power that can be got will advantageously be spent in striking the rock; but on the up stroke the machine itself has in some way to receive the destructive blow. To meet this a common cock is inserted in the lower steam-port, which is from time to time set according to the conditions prevailing, so that only steam or air enough is taken in to bring the piston back without allowing it to strike hard against the upper head. But to leave the exhaust on this same side of the piston free on the down stroke a separate exhaust port is provided on one side of the steam-port, both running into the same common port behind the cock. This arrangement spares the machine and at the same time is economical as to the consumption of air or steam.

3. *Piston packing.*—To insure a tight fit of the piston in the cylinder metal packing rings, E, are inserted into the cylinder. They are double, to break joint, and covered by a third one of spring steel, which tightens them on the piston. In order to get them into their places and hold them there the cylinder is bored larger at the ends, the rings are slipped in, and sleeves, F, put on top of them, and these are held by the cylinder covers. To prevent the two rings from altering their relative positions, and also to prevent them from turning around with the piston, a set screw, G, is tapped through the wall of the cylinder, penetrating loosely into a hole of the rings, where they join. The rings being stationary in the cylinder, combine two great advantages over those that are put in the piston. In the first instance, they are not apt to break on account of the perpetual jarring that they receive when united to the piston; and, further, they always fit the piston. The piston in which a drill is mostly used involves a greater wearing of the cylinder on the bottom side. It will be out of true after some time of use, while the rings, moving to and fro and revolving with the piston, will remain

round, and then a fit is no longer possible. But the piston remaining round, the rings (which are stationary) will always fit it. Lightness and durability are insured.

4. *The rotation.*—A twisted bar, H, enters the upper end of the piston, but is prevented from moving along with it by being held in the upper head, in which it is allowed to turn freely. In order to prevent leakage the inner collar I is made in the shape of a conical valve. On the outer end of the rotation bar a ratchet-wheel, J, is attached; two pawls, K, allow it to turn only in one direction. While one pawl is in gear, the other is in half gear. This arrangement is equivalent to a ratchet-wheel having double the number of teeth, while the strength of the teeth is not diminished. By having thus reduced the pitch of the wheel the back lash is made smaller and the jar on the teeth greatly decreased. Their shape also makes them very strong. In fact, the rotation of the piston, even with the extraordinary speed attained by this drill, is absolutely positive. The twisted end of the bar, in order to give great wearing surface, is made in the shape of a cross or a spindle with four wings on it. These wings are guided by a long brass nut which is screwed into the end of the piston. The twist being right-handed the thread cut on the nut is left-handed, so that the tendency prevails to always screw the nut further into the piston, apparently a small matter, but very important, as it becomes superfluous to secure the nut, which otherwise would get loose in the piston.

5. *The chuck.*—This, marked S, is of the most simple construction. A tapering piece of steel, hardened at both ends, is screwed on the end of the piston-rod. To keep it in place it is split through its entire length, and a steel band is driven on which firmly clasps it on the V-shaped thread. To hold the drill-bit in the chuck two more slots are cut into the latter, but running up only to near the end of the piston-rod. Thus, three elastic tongues are created which inclose the shank of the drill-bit as soon as the lower band is driven on the tapering end. The striking of the drill-bit on the rock has the tendency to tighten these rings continually, making the whole a very simple and secure arrangement. The thread which connects it to the piston-rod is made left-handed for the same reason as that of the nut for the rotation-bar. The rotation of the piston being from right to left, the chuck (if it moves at all) can only tighten itself, and never come off.

6. *The feed-screw.*—This, T, is made unusually heavy and with great surface threads, because the high speed and heavy blow involves intense vibration and jarring of the whole machine.

7. *The tripod.*—The nut *a* of the feed-screw is tapped into the head of a strong bolt, *b*, which holds the cradle *c* in the socket *d* of the tripod. This nut has an octagonal flange, one side of which bears on the bottom of cradle, and thus prevents the nut from jarring loose. The drill, by means of the bolt *b* and socket *d*, may be turned sideways, while the bolt *e* allows it to be swung up and down. A third bolt, *f*,

controls the position of the legs. The two latter, *e* and *f*, are square in their bodies, with beveled heads on one end, while the other carries a conical washer, *g*, under the nut. A glance at Figs. 1 and 3 will show that the square bolt is prevented from turning in the washer *g* as well as in the center pieces; thus the friction of four conical surfaces acts as resistance to turning, making an uncommonly secure joint. The two front legs *h* move simultaneously, because they are kept in the same relative position by the two bolts *e* and *f*. A twisting, and consequent collapsing, of the tripod cannot occur on this account, even if both bolts, *e* and *f*, are loose. In consequence of this arrangement the drill may be pointed in any desired direction, up or down and sideways. The legs are shortened and lengthened in the usual manner, by slipping into wrought-iron pipes, and held fast in them with steel set-screws. Weights, *i*, of proper construction give steadiness to the whole machine, and they are so arranged that they need not be removed if it is necessary to adjust the length of the legs, thus saving time and trouble in setting the tripod.

VICTOR ROCK DRILL.

This machine seems more especially adapted for quarry work. It can be propelled by hand or steam; in either case the drill is driven by its own weight, aided by two spiral springs.

The special advantages claimed are light weight (350 pounds); its peculiar shaped bit, which will always drill round, straight, smooth holes. Two men, with this machine, can do the work of six or eight without it.

Price of machine to drill holes 10 feet deep and from 1½ to 2 inches diameter, $250. Extra charges for bits to bore larger, smaller, and deeper holes than above. The same machine driven by steam, with all appliances, $750. Sold by W. Weaver, Phœnixville, Chester County, Pennsylvania.

WARING'S SELF-FEEDING ROCK DRILL.

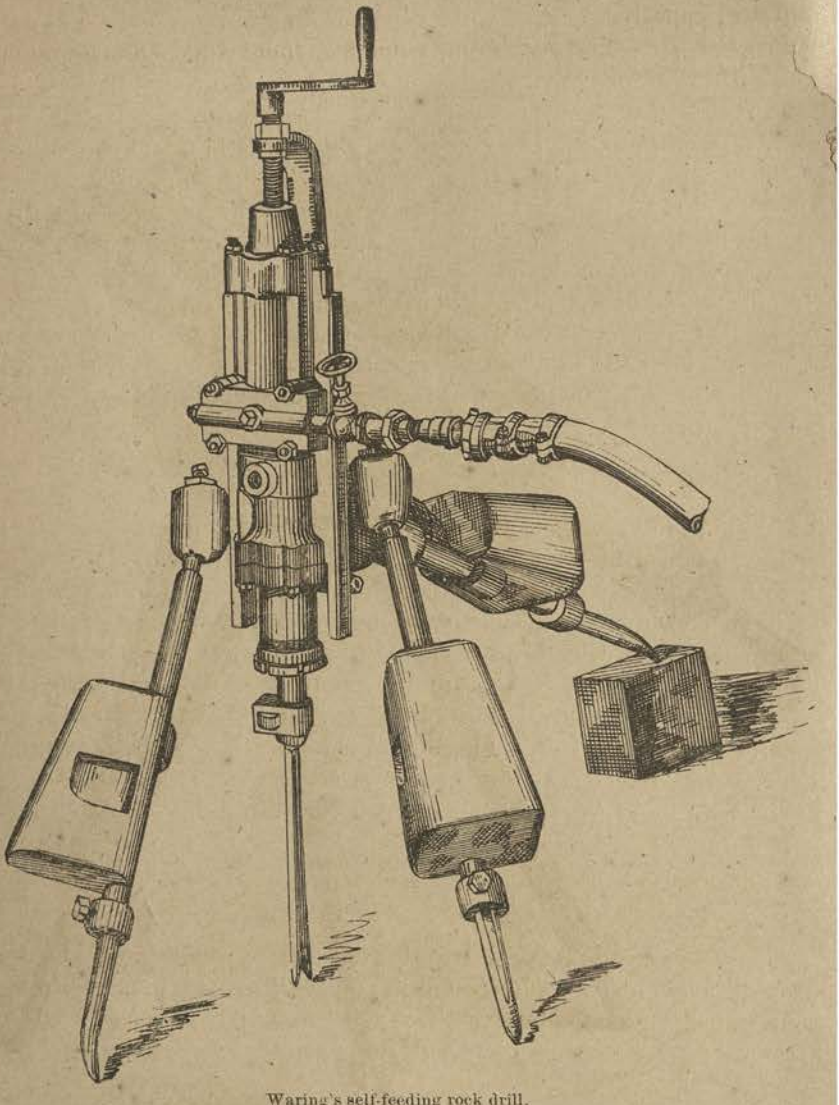
95 Liberty street, New York.

The following advantages are claimed: Great simplicity and great strength, enabling it to be run at any speed from two hundred to one thousand strokes a minute without fear of injury to itself. All its parts are interchangeable; no working parts are exposed except the piston-rod.

For general work the machine is mounted on a new kind of tripod, so constructed that each leg can be moved in any direction; that is, the distance between the resting place of the legs can be varied, thus enabling the workman to put holes just where he wants them.

The drill is secured to the tripod column or carriage by a simple and unique clamp that is operated so quickly that when the drill is to be mounted in places difficult of access a workman should always detach the drill from the tripod, and the work of putting the machine in place is made easy.

The feed is automatic and positive, and will feed the bit to the rock *exactly* as fast as it is cut away. The rotation is positive and will make a round hole invariably.



Waring's self-feeding rock drill.

PRICE-LIST.

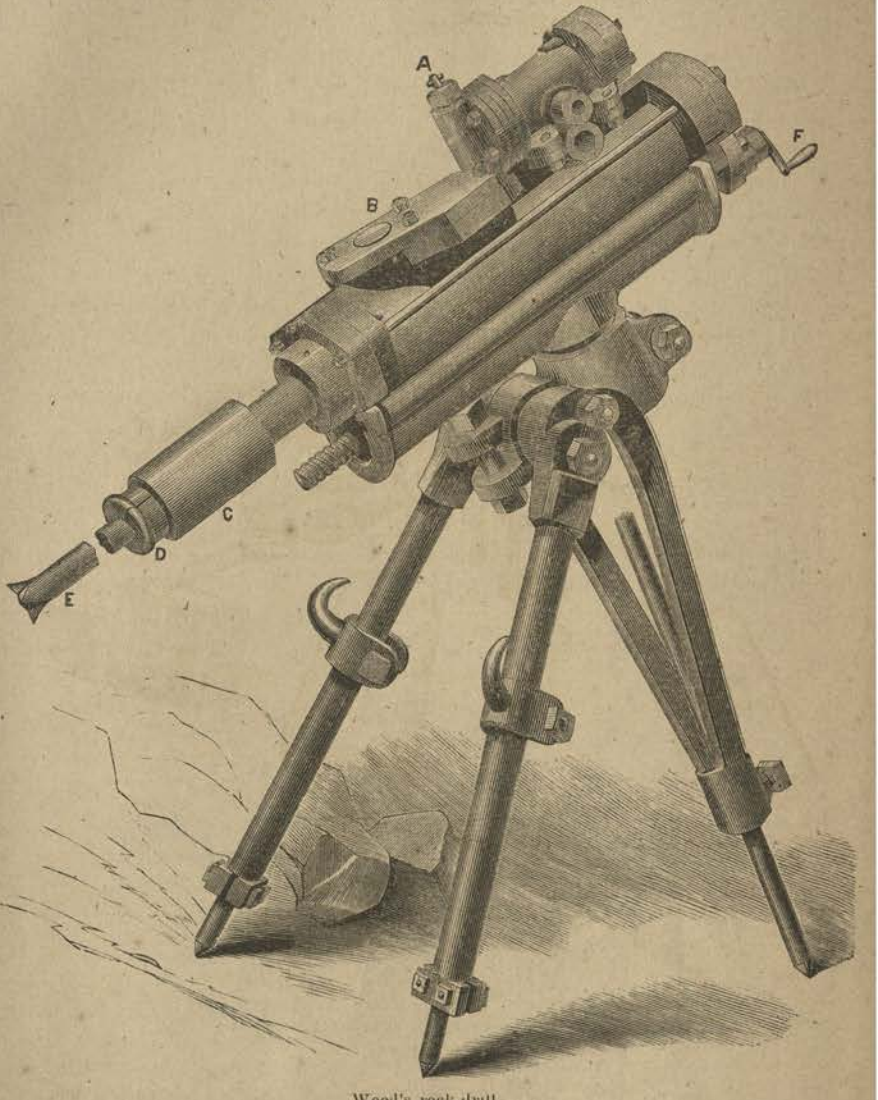
	Price.	Weight.	Will drill holes—
		Pounds.	*Inches. Feet.*
2½ inches diameter drill with tripod or column	$450	175	1½ by 6
3½ inches diameter drill with tripod or column	550	300	1¾ by 12
3¾ inches diameter drill with tripod or column	650	400	2 by 15
5 inches diameter drill with tripod or column	950	850	3 by 30

Columns or tripods, extra, $75 to $100.

WOOD'S STEAM OR PNEUMATIC ROCK DRILL.

The following advantages are claimed: The machines are simple and direct acting, portable, and can be worked at all angles; are durable and drill rapidly.

Peculiarities.—The piston-rod, chuck, or tool-holder, and the ratchet



Wood's rock drill.

for rotating the tool are one single piece of wrought steel and is the only piece which receives the force of the blow. The chuck or tool-holder seizes the tool automatically at the end of the blow, so that if by any means the drill gets loose it will be caught at the next blow.

The length of the strokes can be instantly adjusted when the ma-

chine is running at any speed and the piston can be instantly stopped at either end of the cylinder.

The rotation is secured by the action of a single piece; its action is positive. The feed is perfectly regulated, although it is intermittent in its action. The machine may be easily taken apart or put together. All the principal working parts are covered. The machines are made with interchangeble parts, so that any piece can be duplicated. They are made of four sizes, designated by the diameter of the bore of the cylinder.

The 2¾-inch machine has 5-inch stroke, is 24 inches long, and weighs 155 pounds exclusive of tripod. Price, including tripod, clamp, anchor weights, and one set of drills, $500.

The 3-inch machine is 24 inches long and weighs 210 pounds. It is designed for 1¼-inch to 2½-inch holes, depending upon the hardness of the rock. Price, complete, $550.

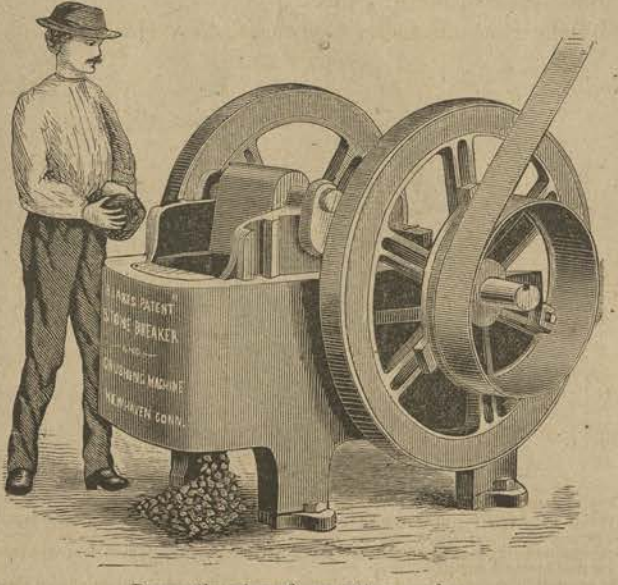
The 4-inch machine is 29 inches long, has a 6¾-inch stroke, and weighs 425 pounds; makes holes of any desired size. Price, complete, $800.

The 5-inch machine weighs 725 pounds; the tripod weighs 200 pounds. It is intended for the heaviest kinds of ordinary work. Price, complete, $900. Address Lewis and Phillips Iron Works, Newark, N. J.

STONE BREAKING MACHINERY.

THE BLAKE CRUSHER.

The Blake crusher is a machine for breaking stones, ores, and other hard substances into fragments of moderate size, used in the construc-

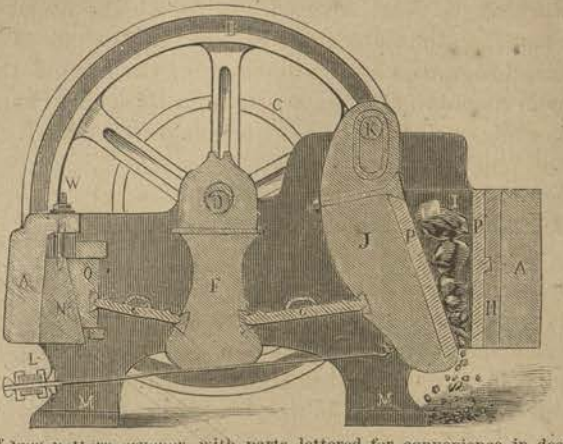


Perspective view of new pattern crusher.

tion of roadways, in ballasting railroads, in preparing concrete, &c. It breaks the stone by means of two upright jaws, set in a massive frame;

one jaw is fixed, the other has a slight vibratory motion. The largest of these machines will break stone weighing half a ton and reduce it to fragments of 5 inches.

The following advantages are claimed: Labor saving; one 15 by 9 machine will produce 100 cubic yards road metal per day, the fragments



Sectional view of new pattern crusher, with parts lettered for convenience in designating pieces wanted for repairs.

A A, main frame; B, fly wheels; C, driving pulley; D, crank shaft; F, pitman; G G, toggles; H, fixed jaw; I, cheek; J, movable jaw; K, jaw shaft; L, rubber spring; N, wedge; O, toggle block; P P, jaw plates; W, wedge nut.

being 1¼ inches in diameter or less. The quality of the product is better. Machine-broken stone for concrete requires 33 per cent. less cement than stone broken by hand.

Made by the Blake Crusher Company, New Haven, Conn.

PRICE-LIST.

Number.	Size or receiving capacity.	Product per hour. (See note.)	Weight of heaviest piece.	Total weight.	Extreme dimensions.			Driving pulley.		Proper speed.	Horse-power required.	Cash price delivered on board.
					Length.	Breadth.	Height.	Diam.	Face.			
	Inches.	*Cu. yds.*	*Lbs.*	*Lbs.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*In.*			
A.	10 by 4	3	1,695	4,000	3 11	3 3	3 9	1 3	6	250	4	$425
*1	10 by 5	3	3,585	6,700	8 4	4 6	5 0	2 0	6	180	5	850
2	10 by 7	5	4,339	8,000	5 3½	3 8	4 5	2 0	7½	250	6	950
*3	15 by 5	6	4,700	9,100	8 7	5 0	5 0	2 4	8	180	9	1,150
*4	15 by 7	6	6,400	10,890	8 7*	5 0	5 0	2 4	9	180	9	1,250
5	15 by 9	7	8,188	14,000	6 5	5 0	5 11	2 6	9	250	9	1,300
*6	15 by 11	7	7,000	11,600	8 11	5 0	5 0	2 4	6	180	9	1,350
8	20 by 15	.....	8,450	32,600	8 6	5 0	6 7	3 6	10	150	12	2,800
*7	15 by 13	(†)	7,165	11,760	9 1	5 0	5 0	2 4	8	180	9	1,400
9	24 by 18	(†)	9,425	37,500	9 10	5 1	6 10	6 0	12	125	12	3,000
10	15 by 12	6	4,400	8,600	4 8	3 7	5 2	2 0	8	230	9	850

NOTE.—The amount of *product* depends on the distance the jaws are set apart, and the speed. The product given in the table is due when the jaws are set 1½ inches open at the bottom, and the machine is run at its *proper speed* and *diligently fed*. But it will also vary somewhat with the character of the stone. Hard stone or ore that breaks with a snap will go through faster than sandstone.

A cubic yard of stone is about 1½ tons.

In getting an engine to drive one of these crushers it is advised to have one of greater power than just what is stated in the table as required. It is much more economical to use 9 horse-power from a 12 or 15 horse than from a 9 or 10 horse engine.

* Nos. 1, 3, 4, 6, and 7 are made of the *old* or *lever pattern* only.

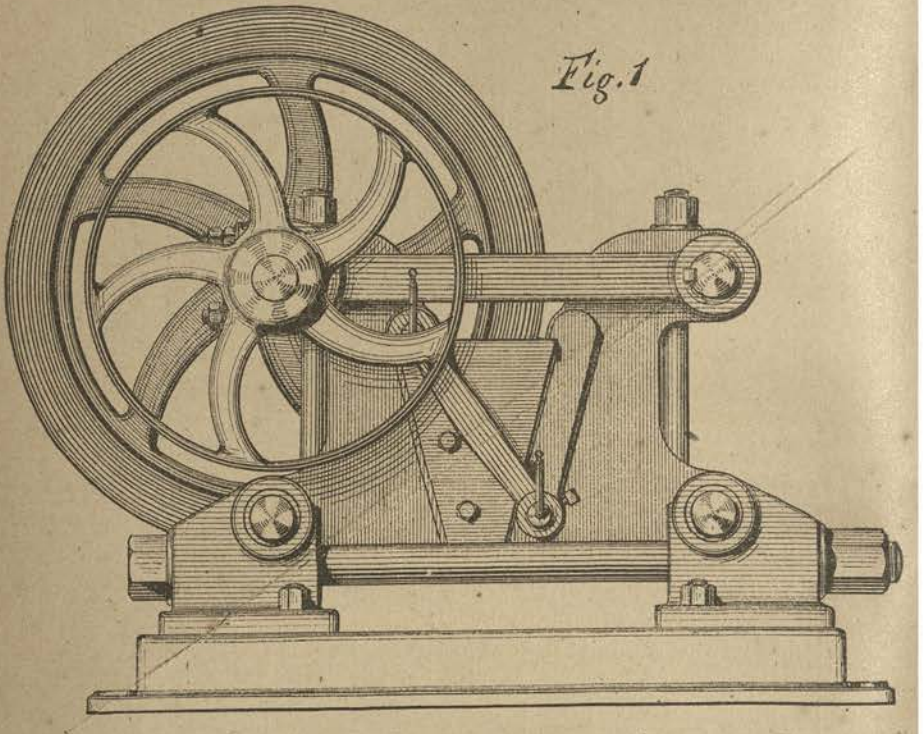
† Coarse or preliminary breakers.

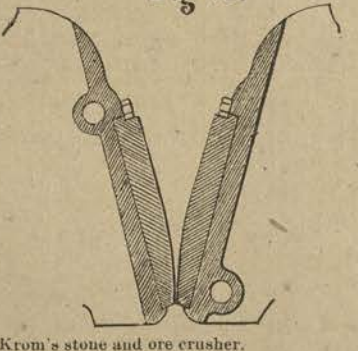
Five per cent. discount from above.

KROM'S STONE CRUSHER.

Manufactured by S. R. Krom, 206 Eldridge street, New York.

This stone crusher was designed especially for crushing ores, but is equally well adapted to crushing any hard stone. What distinguishes

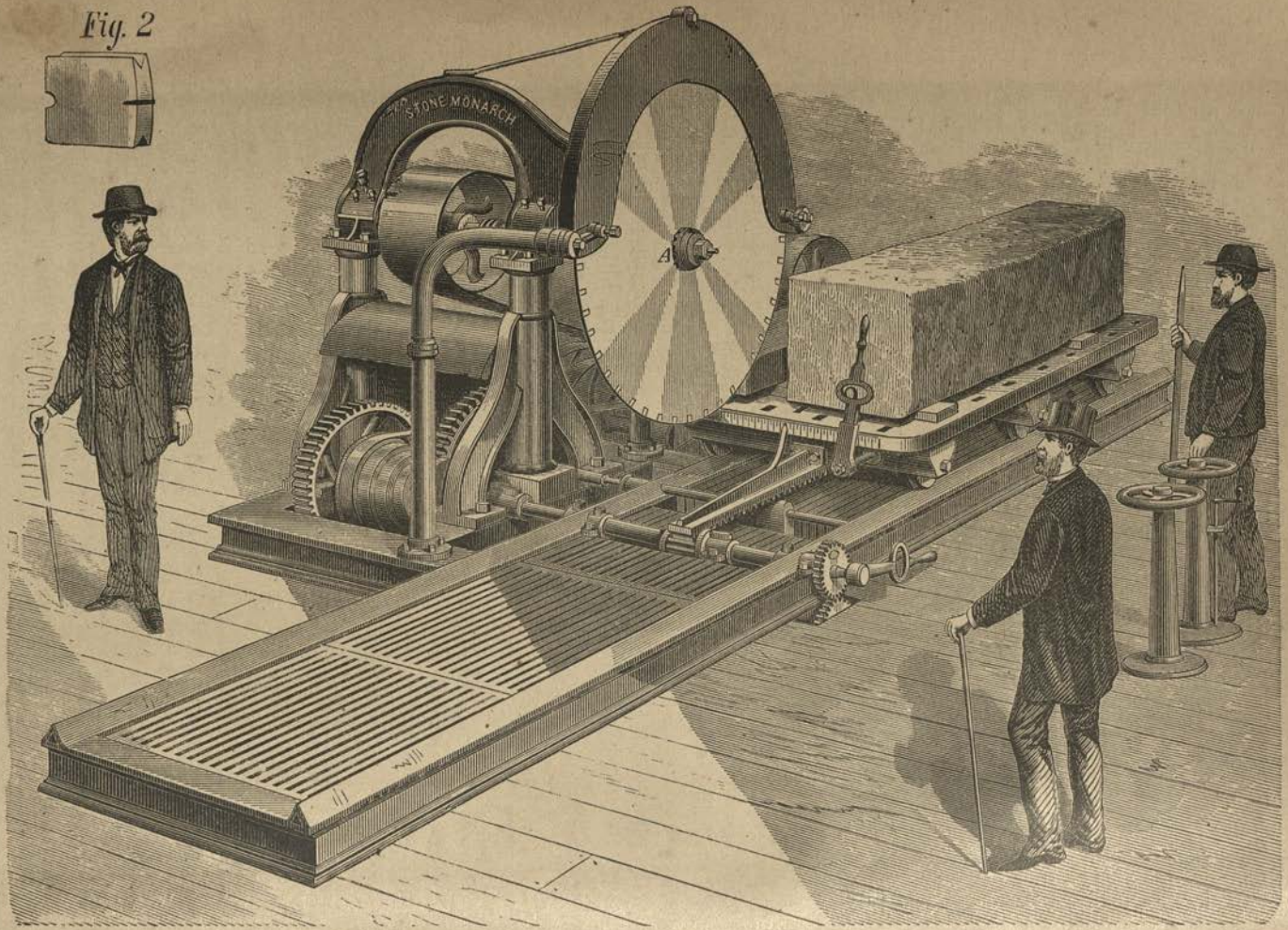




Krom's stone and ore crusher.

this machine from any other is that both jaws oscillate on centers fixed some distance from the crushing faces. The principal feature is the employment of segments of circles between which the ore is crushed on the same principle as rollers act.

Fig. 2



Branch's patent diamond stone-sawing machine. Branch, Crookes & Co., Saint Louis, Mo.

Face p. 593.

It will be seen (Fig. 2) that the lower ends of the crushing plates are true segments of circles, and throughout all the movement of the jaws they remain at fixed distances from each other, but the top parts of the plates recede from each other with straight lines. The crusher can be adjusted by means of bolts so as to produce either fine or coarse crushing.

These crushers are constructed both for laboratory use and for the heaviest kind of work. The larger ones are provided with parts which will yield when undue strain is put upon the machine, and thus prevent any breakage.

STONE CUTTING MACHINERY.

BRANCH'S PATENT DIAMOND STONE-SAWING MACHINE.

The great difficulty in using the bort, carbon, or black diamond in cutting stone has been the forming of a strong junction between the metal of the saw and the diamond.

Among the first attempts was the insertion of the diamond into steel or iron holders with soft metal cushions for the diamond to rest in. These holders were then dovetailed into the edge of the saw disk, and by a wedging device compressed the diamond into the soft metal. These saws worked well for a time, but the soft metal cushions would yield to the pressure of the work and the diamond would work loose. Others have attempted brazing the diamonds into the holders, but the results were no better.

Mr. Branch claims to have overcome this difficulty by fusing the diamond into the holder, the carbon of the diamond and of the steel uniting and rendering the union indestructible. The union is so perfect that the line of junction cannot be distinguished with a magnifying glass. This with the character of the holders and their manner of insertion into the disk of the saw constitutes the chief merit of the invention. The diamond holders are simple in construction and can be set into the saw by any practical mechanic.

The mode of applying water for lubricating the saw when in operation, and washing away the grit and dirt, is novel. The water is conducted through the center of the mandrel into chambers in the saw-collars, which is provided with radial orifices on each side of the saw, and through which the water impinges upon the saw, and by the centrifugal force is distributed over the surface and conveyed to the cut. This effects three results: 1st, keeping the journals of the mandrel cool; 2d, keeping the saw cool and even in temperature, preventing expansion, and, 3d, cleansing from the grit and dirt produced by sawing.

The table, feed-carriage, and ways are simple in construction, and answer the purpose for which they are designed.

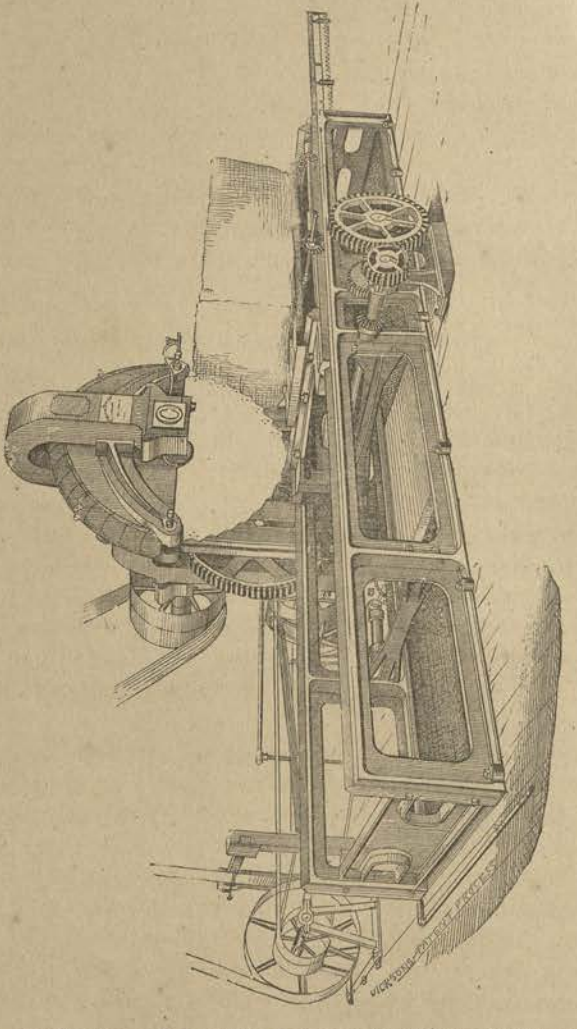
The ordinary free and sand stones are sawed by these machines at

the rate of from 6 to 36 inches per minute; the marble and lime stones from 2 to 18 inches per minute, or an average of 200 to 800 feet per day, making due allowance for the handling of the stone.

The inventor states that he finds but little wear or change in the diamonds after using them two and a half years, what change there was being more due to fracture than wear.

THE DIAMOND STONE SAW.

Made by the Emerson Stone Saw Company, 12 Smithfield street, Pittsburgh, Pa.



This is a circular saw for cutting stone, its distinguishing peculiarity being that its teeth are furnished, like those used in the diamond rock drill, with diamonds which do the work.

The proprietors claim that this machine, doing regular work, cuts in

ordinary sandstone at the rate of 250 surface square feet per hour (counting both sides of the cut), and other stone in proportion, according to relative density or hardness, leaving the stone true and in line, free from spalls and stuns, and ready to be placed in buildings. This is equal to the work of one hundred men in the same space of time, and at an expense not exceeding cost of sharpening and wear of tools necessary to do the same amount of work.

Fig. 1. Holder

The main distinguishing peculiarity of this over other diamond saws is the manner in which the diamond is secured, which is as follows:

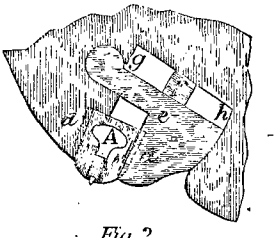


Fig. 2. Saw tooth

The diamond (Fig. 1) is embedded in a small piece of copper, which is held by the jaws *c c* of the holder A. The holder A (Fig. 2) is held in its position in the saw-tooth by the clamp *e*, tightened by the wedge *f*, which can be moved in the open space from *g* to *h* for this purpose. It will be noticed that this open space is a little narrower at *h* than at *g*.

YOUNG'S RECIPROCATING DIAMOND SAW MACHINE.

Hugh Young, foot of East One hundred and seventeenth street, New York.

The principle of this invention may be broadly stated as follows: That the diamonds are made to act upon the stone in such a manner as to receive pressure in one direction only. While operating the blade under this method there has never been felt the want of any better mode of fastening the diamond than the ordinary and simple practice of brazing.

In the construction of machines the above principle as to the reciprocating blade is carried out by causing it to be withdrawn from contact with the stone before and during its return stroke, and bringing it back into contact with the stone only at the beginning of the next cutting stroke.

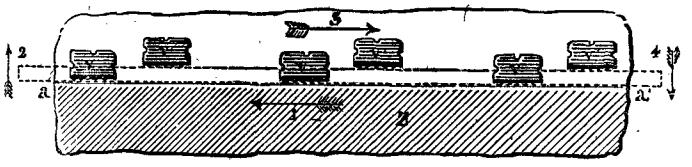
In the preceding diagram Z represents the stone to be cut, V represents the cutters, carrying the diamonds, when acting upon the stone, and V′ represents the same cutters held away from contact with the stone on the return stroke.

The cutters V first plow their way upon the stone Z (arrow No. 1), making the cutting stroke *a′ a*; then are withdrawn and held away from the stone (arrow No. 2), while making the return stroke (arrow No. 3), and finally are brought down to their work (arrow No. 4). The movements indicated by arrows Nos. 1 and 3 are the cutting and return strokes, or the reciprocating motion of the blade; those indicated by Nos. 2 and 4 are the push and lift motion.

It will be obvious to any one carefully observing the above that all the pressure applied to the diamonds has a tendency to embed them more

firmly into their sockets instead of dislodging them, as would be the case were the pressure applied alternately from both directions.

So much for the theoretical statement; but, as developed in the mechanical application, both in the patent and in the practical construc-



tion, this movement is executed in a way still more favorable to the diamonds.

1st. The diamonds are brought down to their work, not at a right angle, but on a gentle curve, the result of urging the downward push motion and the beginning of the cutting stroke.

2d. The beginning of the cutting stroke and the push motion, acting in unison as above, are effected by the crank at the time of passing the dead center, thus allotting the longest time for the push action and the slowest part of the forward movement to the entering of the diamonds upon their work.

3d. The feed movement of the machine is made to act only during the time of the cutting stroke, thus still further subdividing the work put upon the diamonds.

As illustrating this exceedingly minute subdivision of the work of the diamonds, it may be mentioned that when cutting with a feed of 30 inches per hour, each stroke removes only $\frac{1}{140}$ of an inch, which makes an allotment of $\frac{1}{21\,0\,0}$ of an inch of downward work to each diamond in the saw.

DESCRIPTION OF THE MACHINE.

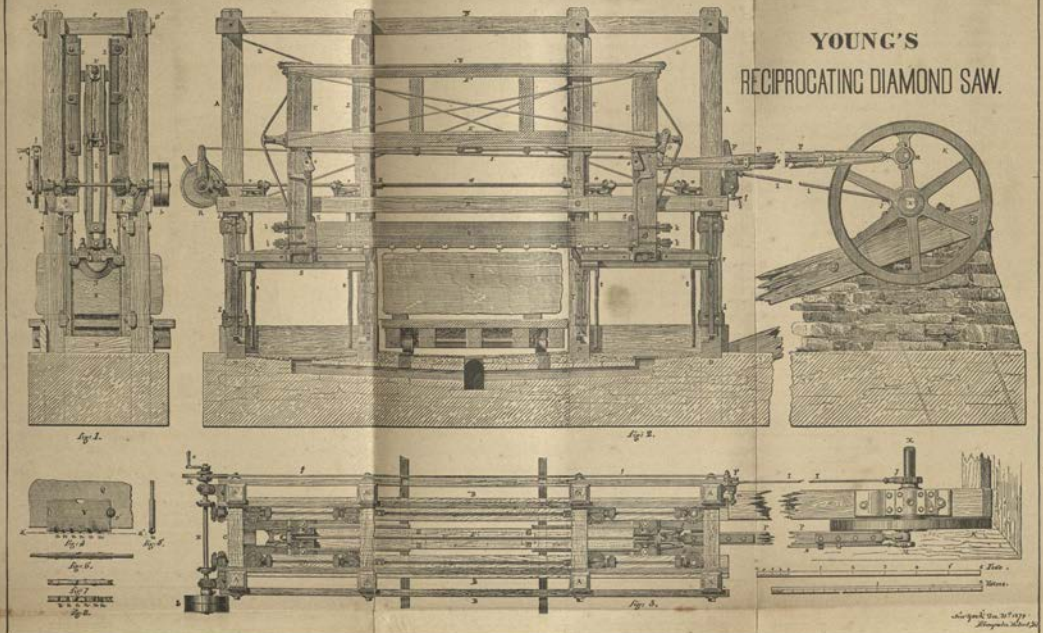
Referring to the plate, Fig. 1 is an end view of the single-blade diamond saw machine; Fig. 2 is a sectional elevation of the same; Fig. 3 is a top view of the same; and Fig. 4, 5, 6, 7, and 8 representing a cutter block armed with diamonds seen in different positions.

The frame of the machine is of timber. It is composed of eight posts, A, firmly planted in a concrete foundation, and united by the horizontal pieces B B′ and transverse pieces C and D; the whole thoroughly framed, bolted, and braced to stand square, plumb, and rigid.

The guiding vertical slides Y and T are made adjustable and firmly bolted to the posts A. The slides S, suspended at the four corners on the cuts of the screws *t t t t*, work between, and are guided by, the slides Y and T. The eight screws *t* are connected together by the gears *o*, shaft G, and shaft H, which, when turned in one direction or the other, will cause the slides S to rise or fall in a perfectly parallel manner.

For raising or lowering the saw, the shaft H may be turned by hand with the handle *c*, or by steam power with the pulley *b*; but for feeding the blade down into the stone the shaft H is turned automatically by the

YOUNG'S
RECIPROCATING DIAMOND SAW.



A. Posts of the frame of the machine.
B B'. Horizontal pieces of the same.
C and D. Transverse pieces of the same.
a. Diagonal brace bolts.
Y and T. Vertical slides for slides S.
S. Horizontal slides suspended on nuts of feed screws t.
o. Gears working screws t.
G. Long shafts connecting gears o.
H. Transverse shaft connecting shafts G.
c. Handle for turning shaft H by hand.
b. Pulley to receive a belt for turning shaft H by steam.
R. Rachet wheel for turning shaft H by action of machine for feeding
J. Feed eccentric.
I. Feed rod.
F. Variable feed rock lever.
j. Feed rod on machine.
E. Sash end pieces.
E'. Thrust piece of sash.
E''. Top piece of sash.
K. Crank wheel.
P. Pitman.
Q. Blade carrying diamond cutters V.
k. Buckles for stretching blade.

RELATING TO CUSH AND LIFT MOTION.

M. Eccentric on crank pin.
N. Rod on pitman.
o. Lever.
x. Link.
t. Rod on sash.
s. Cam levers.
q. Pushers.

action of the machine itself through the eccentric J, rod I, rock-lever F, rod *j*, and ratchet-wheel R.

The sash-frame is composed of two end pieces E, thrust-piece E′, and and top piece E″, well fitted, bolted, and braced. It is mounted on suitable blocks, so as to slide freely and truly upon the horizontal slides S, and receives a reciprocating motion upon said slides S from the crank-wheel K, through the pitman P.

The blade Q is mounted and tightly stretched in the sash-frame by the buckles *k*, and, moving with the sash, receives the go and come rectilinear motion, which we call the cutting stroke and return stroke.

The push and lift motion, or that motion which, alternating with the cutting and return stroke, is given to the saw-blade to push it to and hold it in contact with the stone during the cutting stroke and to lift, and keep it away from the stone during the return stroke, is accomplished by the action of the eccentric M on the crank-pin, transmitted through the rod N, lever O, link *a*, rod *i*, levers *s s*, and pushers *q q*.

The cutter-blocks V are made of steel, and so shaped and adjusted into the blade Q as to be readily taken out and replaced for the purpose of setting the diamonds therein, and are held fast in their places by soft metal rivets as represented in Fig. 4.

Fig. 8 represents the cutter-block V seen from the lower edge, showing the appearance of the diamonds *n* when set in it.

Fig. 7 is the same cutter-block seen from the top edge, illustrating the projection of the diamonds each side of the metal.

Fig. 6 is the same cutter seen from the same point of view, but surrounded by a small section of the blade Q, illustrating the projection of the cutter-block each side of the blade Q.

Fig. 5 represents the same cutter-block and section of blade seen from the end thereof; and

Fig. 4 is again the same cutter-block and piece of blade in front view. In this figure the dotted line *a′ a* is the cutting line or bottom of the kerf, *n* are the diamonds as they appear projecting from the steel cutter-block and *r* is the soft metal rivet used for holding the cutter-block V firmly in the socket of the blade Q.

In order to assist in clearing the *debris* from the kerf, and keeping the diamonds cool, small streams of water are used, which are directed to the proper place of operation by gum pipes connected with a distributing pipe and regulated by stop-cocks.

The main shaft X, a portion only of which is represented in the illustration, is firmly mounted on suitable adjustable pillow-blocks, and carries (besides the crank wheel K and eccentric J shown in the drawing) a heavy balance fly-wheel and a pair of driving pulleys, loose and tight, for receiving the driving belt.

RESULTS.

The downward feed of the saw varies according to the hardness and impenetrability of the stone, from 3 inches in Scotch granite to 5 feet

per hour in soft freestone. In Connecticut brown granite the average is about 2 feet 6 inches per hour, equal to an average of 200 superficial feet of sawing per day of ten hours for one machine, with two moving tables.

By cleaving stone to a double thickness, the saw makes two available faces at once, thus facing 400 superficial feet of ashler per day; or, if the blocks are such as to average three faces to two cuts, 300 feet of ashler per day. It makes no material difference in the rate of feed whether the whole length of the saw is occupied or only a part of it, nor whether it operates on one long stone or on a number of small ones.

PRICE LIST.

Prices of Young's single-blade diamond saw machines, including licenses for using them without further royalty.

To cut 8 feet long by—	
3 feet high	$4,500
4 feet high	4,700
5 feet high	4,900
To cut 9 feet long by—	
3 feet high	4,700
4 feet high	4,900
5 feet high	5,100
To cut 10 feet long by—	
3 feet high	4,900
4 feet high	5,100
5 feet high	5,300
To cut 11 feet long by—	
3 feet high	5,100
4 feet high	5,300
5 feet high	5,500
To cut 12 feet long by—	
3 feet high	5,300
4 feet high	5,500
5 feet high	5,700
To cut 13 feet long by—	
3 feet high	5,500
4 feet high	5,700
5 feet high	5,900

Add to the above prices $100 for each parallel moving table required.

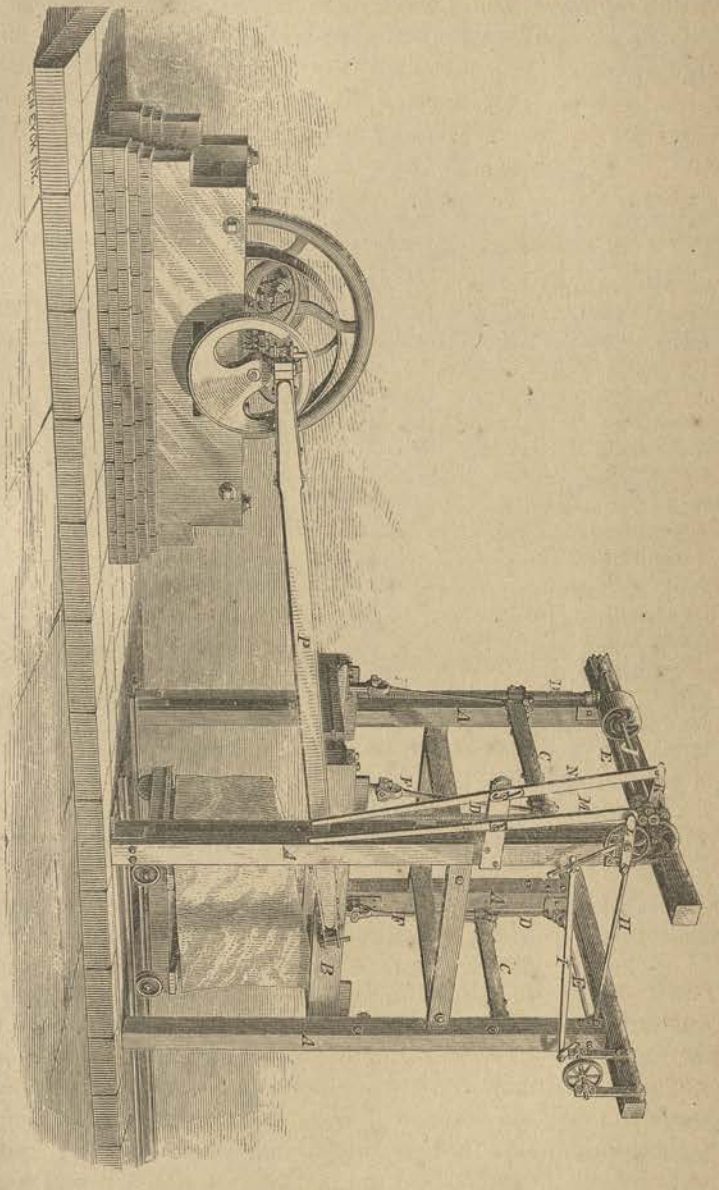
These prices are without power, water supply, or belts, but set up complete in every other respect and made ready for work, including blade and diamonds complete, an extra set of cutter-blocks without diamonds, and instruction in running machine and setting diamonds.

The purchaser, however, will dig foundations, furnish rough labor, help in erection, and furnish and lay masonry; also pay freight from New York and the board and railroad fares of the men sent to erect the machine and teach its use.

THE MERRIMAN PATENT GANG FOR SAWING STONE.

Thomas Ross, manufacturer, Rutland, Vt.

The principal advantage claimed is that the frame or sash which carries the saws is fed down to the stone by an automatic feed capable of



The Merriman patent gang for sawing stone.

ready adjustment to stone of different degrees of hardness, and, at the same time, is held firmly down while in action, so that the pressure of the saws upon the stone is uniform and not dependent upon the weight

of the frame; this construction also counteracts the thrusting action of the pitman upon the frame, which becomes excessive when the saws are at the top or bottom of a block, causing a jumping motion of the frame and saws, largely neutralizing their cutting action and destroying the machine itself. This feature also allows the machine to be safely run at an increased speed.

The cut shows a gang actuated by two pitmen, attached to both sides of the frame.

THE STACY STONE-DRESSING MACHINE.

Address A. J. Fisher, 98 Nassau street, New York.

The engraving gives some idea of the construction of the machine; but it is impossible to show with accuracy the operation of the cutters on so small a scale. The cutting cylinders carry hinged cutter-stocks, arranged spirally. The cutters are secured in the heads of the stocks and when worn can be quickly changed.

The action of this machine is entirely due to a mechanical movement, which gives a blow similar to that given by hand without that excessive wear and tear, either on the machine or tools, attendant on machines heretofore constructed for dressing stone.

In working the machine, the stone to be cut is laid upon the carriage and the feed-motion adjusted, as the character of the stone and the work to be done may require, and the machine started.

The first cylinder takes off the rough stone, the second smooths it sufficiently for ordinary use.

When a very smooth surface is required similar to that produced by the rubbing-bed, the finishing cylinder may be used.

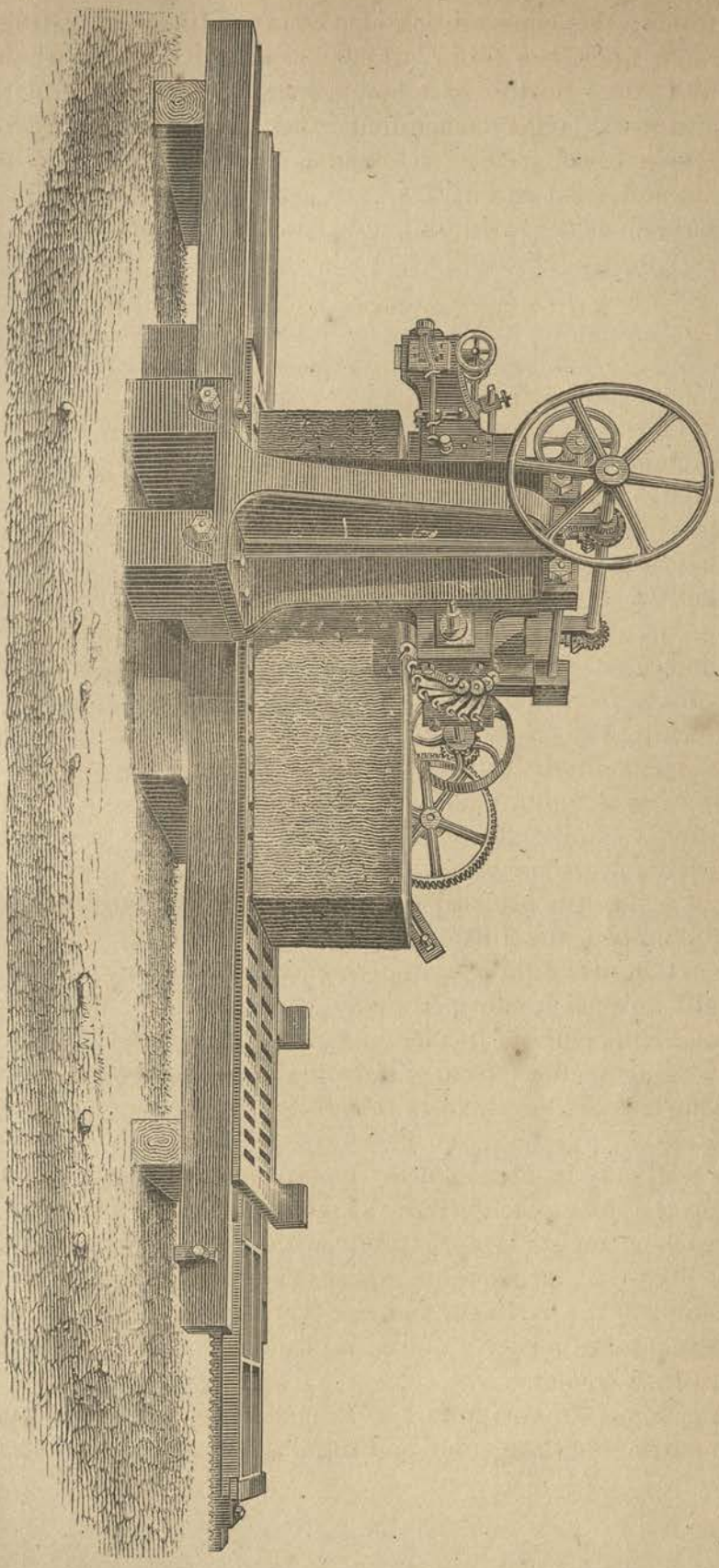
The action of the three cylinders may be simultaneous and the stone is usually finished at one operation. As each cutter comes round, it strikes the stone in the plane of its face, and instantly rebounds, the rapidity of its motion being such as to carry it during its rebound over the inequalities of the surface of the stone so that it will strike but once during each revolution.

The feed may be arranged to allow the cutters to strike once or more times in the same place before the stone is fed forward.

As each cutter strikes separately with a very light blow, thin stones can be dressed, and stones of any considerable weight do not require to be secured to the carriage, and can therefore be rapidly handled.

The amount of power required is small, not exceeding 3 horse power for a 24 inch machine.

The machine dresses from 4 to 12 inches linear per minute, according to the hardness of the stone and the finish required.



Stacy's stone-dressing machine.

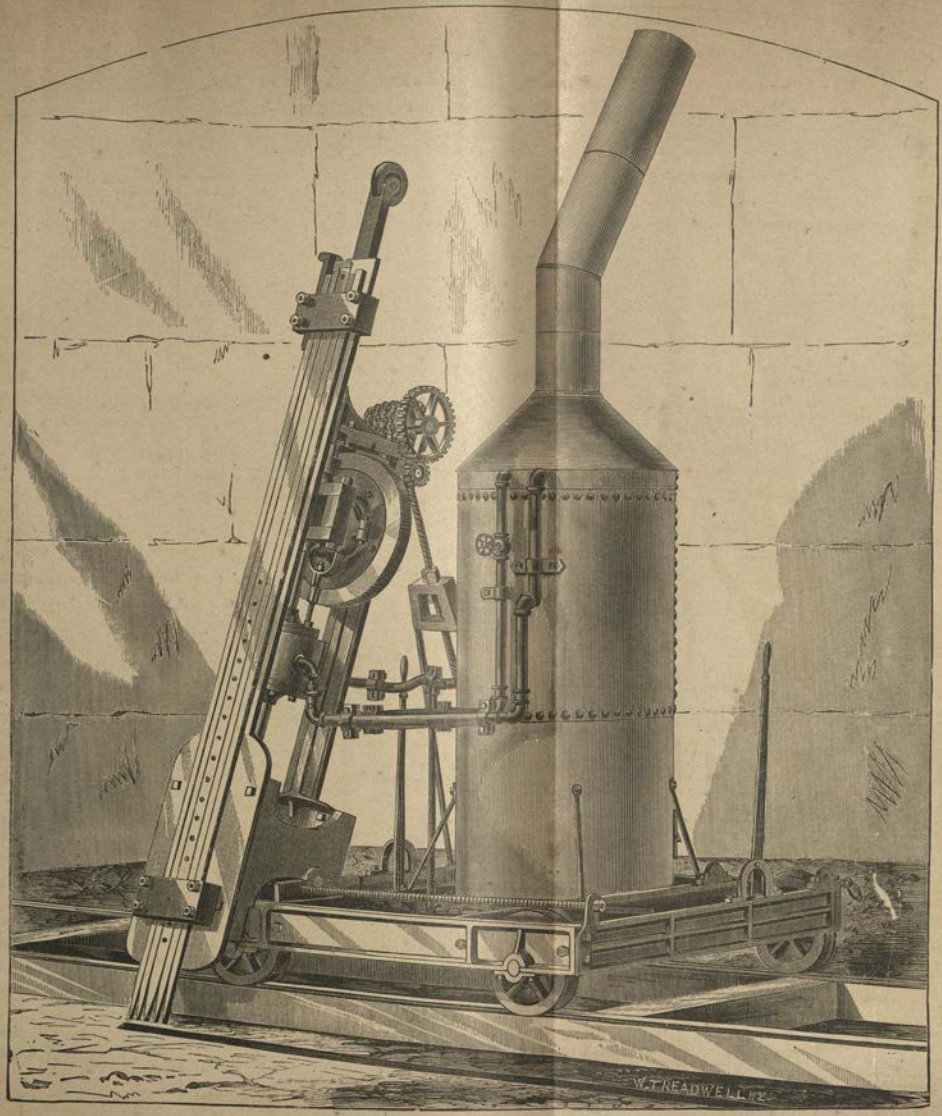
THE WARDWELL STONE CHANNELING AND QUARRYING MACHINE.

Manufactured by the Steam Stone Cutter Company, Rutland, Vt.

The following is a description of the double gang machine, as represented mounted upon its track on the bed of the quarry:

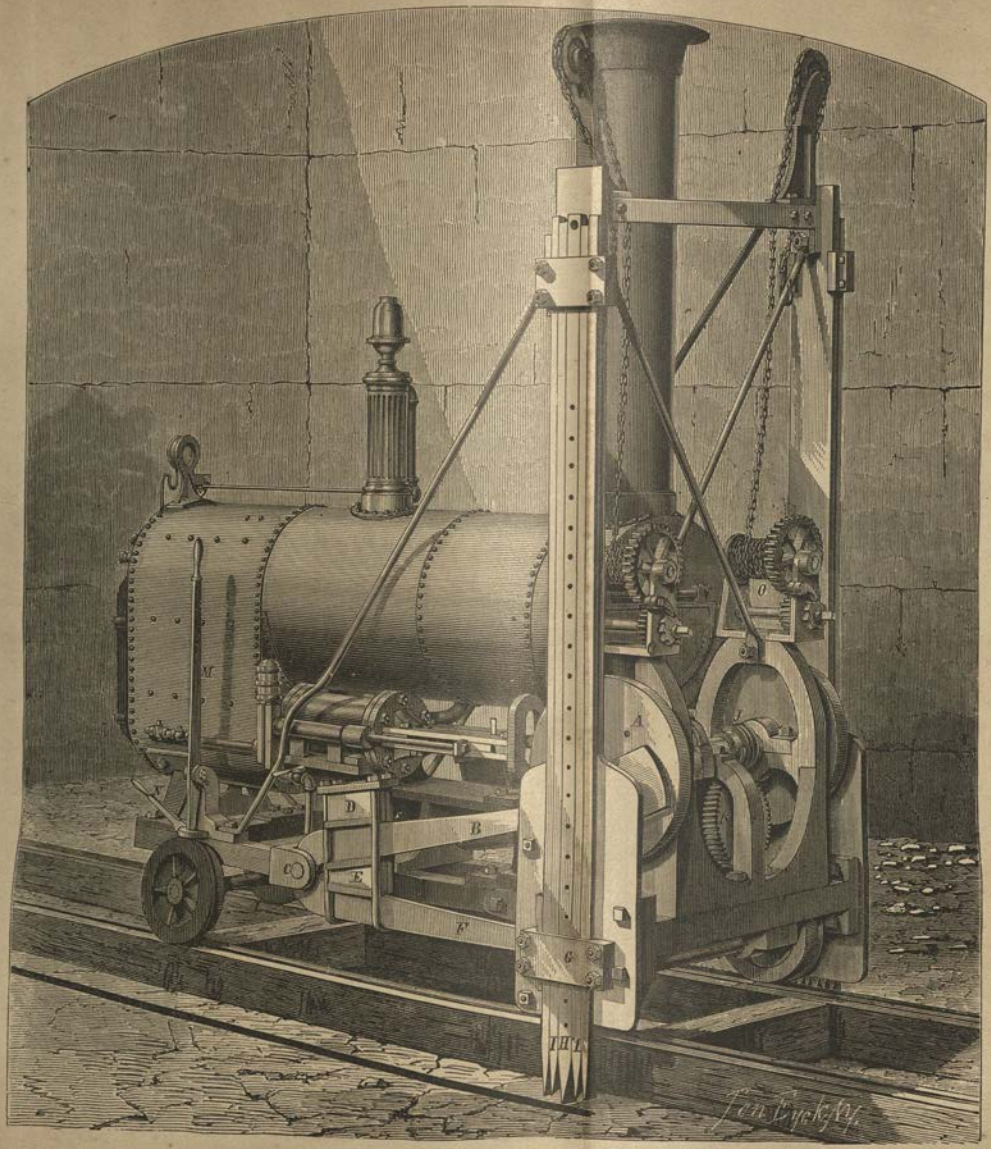
The frame which supports the boiler, engine, and other machinery consists of one piece of forged iron, weighing nearly a ton, thus furnishing great strength and durability. The engine is of 6 horse-power; its shaft carrying a balance-wheel, A, on each end, to which is attached an adjustable wrist-pin plate. B and F are levers pivoted at their rear ends to the frame at C. The free end of the lever B passes through a sliding stirrup or swivel attached to the wrist-pin (not shown), giving an up-and-down motion to that end of the lever as the balance-wheel A revolves. The free end of the lower lever F passes through a mortice in back side of lower clamp G. Motion is communicated from the upper to the lower lever by means of clasps, between which the rubber springs D and E are placed, as shown in the engraving. The free end of the lever F actuates the gang of chisels, which consists of five bars of the best cast steel, sharpened at their lower ends, and clamped together by head-and-foot clamps; the whole sliding freely on the standard. Of the five chisels two, I I, have diagonal cutting edges, and three have their edges transverse. The middle chisel H extends the lowest, and all together form a stepped arrangement each way from the center. Thus it will be seen when the machine is moving forward the front three cutters, which includes the middle one, H, operate; while moving in the opposite direction the other two, with the middle one, H, perform the work. The object of the diagonal cutting-edges is to insure an even bottom to the channel. These bars of steel are from 7 to 14 feet in length, according to the depth of the channel to be cut. The upper ends of these bars are separated, to match corresponding separations in the head clamp, for the purpose of preventing any displacement of the cutters while in use. J is a worm on the main shaft, and actuates the toothed wheel K. The shaft of the latter extends diagonally downwards to the rear of the machine, where it terminates in a level pinion; upon the rear axle are placed two beveled gears, one of which is shown in part of L. By means of the lever M either of these beveled gears may be thrown into action with the pinion. It will be readily understood that the motion thus communicated serves to turn the axle either backward or forward, according to which wheel engages the pinion. When the machine is required to be stationary these beveled gears are so placed as not to engage with the pinion. The short lever N locks these beveled gears in either of the desired positions. The windlasses O O on each side of machine are for raising the gangs of cutters out of the channels. The opposite side of the machine is, of course, the same as that already described.

The length of the double gang machines is 10 feet, and they are made of three different widths, respectively, to cut channels 4 feet 1 inch, 6 feet 3 inches, and 6 feet 7 inches apart, and cut two channels at once.



Face p. 602.

Single gang machine.



Face p. 602.

Double gang machine—reduced price, $5,000.

The length of the single gang machine is 7 feet, width 6 feet, and it cuts either vertical or inclined channels down to 45°, and the cutting apparatus with its operating machinery is made adjustable for operating upon either end of machine, thereby making it a right or left handed machine, adapted to cut in all corners.

The single machine strikes 150 and the double 300 blows (150 on each side) per minute, and feed forward on the track one-half inch at each stroke, or 6 feet per minute, and cut from ½ inch to 1 inch in depth (according to the stone) each time over.

The single machine cuts from 40 to 80 square feet of channel in marble and limestone, and 80 to 100 in sandstone per day. The double machine cuts from 75 to 150 square feet of channel in marble and limestone, and 150 to 200 in sandstone per day.

Machines for sharp grit sandstone are fitted expressly for that purpose with short guides and cutters specially adapted for that stone.

Each alternate tier of blocks can be cut of any desired width by placing the machine a greater or lesser distance from channels previously cut, or channels can be cut between, thus giving a great variety of sizes, even with double machine.

The channels cut are straight and true, like a tooled face. The stone is all saved in quarrying with these machines. Clean, open channels can be cut with these machines for less than half the net cost of any other process.

The machines are mostly wrought iron, and made in the most substantial manner, and in the hands of skillful operators need few repairs, as the concussion from the blow is confined to the gang of cutters and completely cut off from the machine by the intervention of the compound yielding levers with rubber springs, which are connected to and operate them.

TESTING APPARATUS

FOR DETERMINING THE COMPRESSIVE, TENSILE, AND TORSIONAL STRENGTH OF MATERIALS.

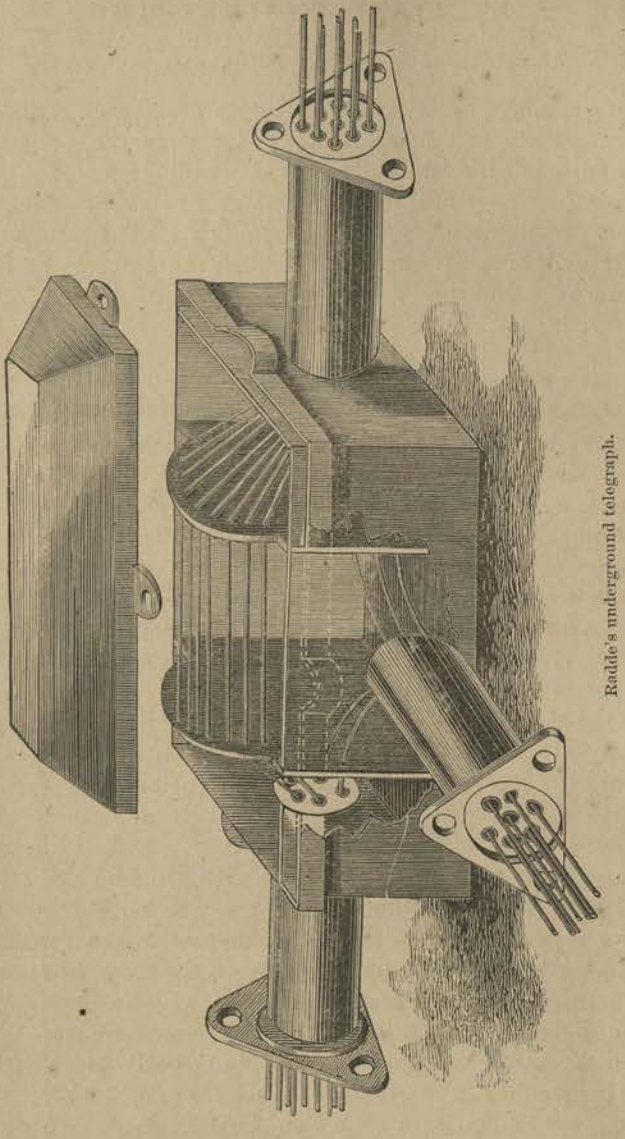
Made by Riehle Brothers, Ninth street above Master street, Philadelphia.

This firm has constructed apparatus to make the above tests, and on application will furnish an illustrated circular giving sizes of the specimens they are prepared to test. Their charges are for each test for compressive or tensile strains, $1 to $2; for torsional strains, $3.

UNDERGROUND TELEGRAPH.

The plan for an underground telegraph, devised by William Radde, 548 Pearl street, New York, is ingenious, and is noticed here as it might be used on shore in place of the multiple cable in the Army torpedo system.

It consists of iron pipes containing small glass tubes held in position by paraffine wax. Through the tubes naked copper wires are drawn. For lateral connections, as well as convenience in laying, traps are used into which the pipe is screwed, the wires passing over non-conducting



Radde's underground telegraph.

bridges, thus allowing any wire to be taken out and replaced without interfering with the working of others. The pipes are connected with a coupling, which, after being bolted together, is completely sealed; the traps are closed and sealed in like manner.

MILITARY ENGINEERING.

Capt. JAMES C. POST, Corps of Engineers, U. S. A.

Military engineering as shown at the International Exhibition comprises the subjects of armor plating, the construction of barracks and fortifications, and the formation of bridge equipages.

These will be described in the order named, and are exhibited by the Governments of Russia, Spain, Sweden, the United States, the Atlas and Cyclops Works of Sheffield, England, the Morgan Iron Works of New York City, and the establishment of Fried Krupp, of Essen, Germany.

ARMOR PLATING.

The English exhibit of armor plating is made by the Atlas Works of Messrs. John Brown & Co. and the Cyclops Works of Messrs. Cammell & Co., of Sheffield, England, which have been engaged for years past in rolling plates for the English war vessels. Four plates are exhibited by the former and three by the latter, all of the specimens except two being plates that have been submitted to tests, the effects of the shot being shown.

The thinnest plate exhibited, 2 inches thick, made by Cammell & Co. is a portion of the deck-plating of the new English war vessel Inflexible and was tested with a 6-pound S. B. gun. Three shots fired with a 6-pound spherical shot, a charge of 1½ pounds R. G. L. powder, and with a range of 30 feet, resulted in an average penetration of about 1½ inches with a bulge at the back of 1 inch, the plate being badly cracked.

The next in thickness, two 8-inch plates, one from the establishment of Cammell & Co., and made for H. B. M. S. Rupert, and the other made by John Brown & Co., were both tested with the 8-inch S. B. 68-pound spherical shot, charge of 13 pounds powder, and range of 30 feet. Nine shots were fired at each with about the same results, that is, an average penetration of 2½ inches, 1½ inches bulge on the back with cracks.

The 9-and 11 inch plates, the former made by John Brown & Co., and the latter by Cammell & Co., for H. B. M. S. Temerairo, were tested with the 7-inch M. L. R. gun, charge, 14 pounds R. G. L. powder for the former and 18½ pounds for the latter, with a range of 30 feet. Four Palliser elongated chilled iron shot were fired at each, with an average penetration of 7 inches, the former having a bulge of 2½ inches at the back, and being considerably cracked, while the latter had a bulge of only 1 inch, and was without cracks. The edge of the holes in both are ragged, and there is no indication of a separation of the different layers of which the plates are formed.

The 14-inch plate exhibited by John Brown & Co., and which has not been tested, is a specimen of thickest plate that establishment had rolled up to October, 1876. During that month, however, they succeeded in rolling a plate 24 inches thick and 10 feet in width, which is now the thickest and widest plate that has yet been rolled by any establishment.

The piece 21⅝ inches thick in the collection of Cammell & Co., is a portion of the plate made for the Italian Government, and tested recently at La Spezzia with the 100-ton Armstrong gun. This gun, fired with a charge of 341 pound powder, and a shot weighing 2,000 pounds, completely pierced this plate, the strong backing and 30-inch spin of target, the resistance of which is supposed to equal the sides of the great Italian iron-clad Duilio.

The only other specimen of armor plating to be found in the exhibition is one from the Morgan Iron Works of John Roach & Son, New York City. This plate, 10 feet long, 3 feet 8 inches wide, and 12¾ inches thick, represents the iron plating to be used on the iron-clad Puritan, now constructing at Chester, Pa. There being no rolling-mills in this country capable of rolling a plate of this size, this specimen was forged. It is now, however, intended to attach to the rolling-mill at Chester, Pa., the necessary machinery for rolling plates of this thickness.

Recent results showing the wonderful penetrative power of the heavy ordnance now being experimented with, the targets representing the heaviest plated vessels having now been pierced, has again brought up the question of the desirability of increasing at the expense of flotation the thickness of the armor-plating of vessels of war beyond that already made. The following remarks upon this subject, showing the immense flotation now required for the thickest plated vessels, are taken from the Engineering Journal, which quotes from the London Times:

The double turret ship Inflexible, designed as an improvement upon the Russian Peter the Great, will herself be surpassed by the two Italian iron-clads which are building at La Spezzia and Castlemore. We, of course, are speaking of thickness of armor, and not of the other questions discussed between Mr. Reed and Signor Matteo. While the Inflexible's turrets are formed of a single thickness of 18-inch armor, and her armament consists of four 81-ton guns, the turrets of the Dandola and Duilio are built of plates 22 inches thick, and are armed with four 100-ton guns, 30 feet long, and having a caliber of 19 inches, manufactured by Sir William Armstrong & Co., and, with a charge of 300 pounds of powder, are supposed capable of carrying a shot 2,000 pounds in weight. Nor is this all, for the manufacturers of the armor for the Italian ships, Messrs. Cammell & Co., of Sheffield, have publicly stated that they are willing to roll solid plates 30 or 40 inches in thickness as soon as a gun has been constructed of sufficient energy to penetrate their 22-inch plates, and the challenge will probably be accepted sooner than they anticipate. For the moment the advantage seems in favor of armor, but its supremacy is being gradually undermined by the gunnery experiments at Dulmen. A few months ago the 35½-centimeter Krupp gun, although weighing only 57,500 kilograms, pierced a target representing the citadel of the Inflexible, that is, 24 inches of iron in two thicknesses, at a distance of 1,800 meters. Where this competition between guns and armor is likely to end it is impossible to say, but as far as the exigencies of the Navy are concerned the limit of weight seems to have already been reached, for the simple reason that the buoy-

ancy of our iron-clads cannot with safety be further diminished by the burden of heavier armor and armaments. If we add to the weight carried for defense, we must either reduce the nature or number of the guns or dispense with them altogether, depending entirely upon the effect of ramming; since it is clear that it would be undesirable for many reasons to add to the size of our sufficiently unwieldy irons-clad, the more especially as a great proportion of their hulls is mere floating material, rendered necessary to support the armored forts. Hence, to increase the weight of the armor and the batteries inevitably adds to an enlargement in the dimensions of the unprotected parts of the ship. The Sultan, with its 9-inch armor and twelve guns, has a displacement of 8,899 tons, but the Devastation with 12 inch armor and only four guns, has a displacement of 9,062 tons. In the case of the Inflexible a total length 320 by 75 feet is required to float a citadel 110 feet in length by 75 feet; and although the design in her construction was to put a battery on a thin iron ship, merely protecting the vitals with armor plating, she will have, when all her weights are on board, the enormous displacement of 11,407 tons.

The experiments made at Shoeburyness during the past month to test the accuracy and range of the 81-ton gun, now that its caliber has been increased to 16 inches, have been completed with entire satisfaction to the committee in charge. The mean deviation was found to be exceedingly small, and the range, 1,100 yards, an average of five shots fired at 1° elevation, and 3,000 yards, an average of five shots at 4° elevation. Being fired over water, the shots ricochetted, and, in some instances, the second point of contact was from 12,000 to 13,000 yards from the point of firing. Its ultimate calculated capacity is a penetration of 27 inches of solid armor at a range of 1,000 yards with a shot weighing 1,000 pounds. As soon as a target can be constructed for this purpose experiments will be at once commenced to test this power of the gun.

KRUPP'S CANON À CUIRASSE.

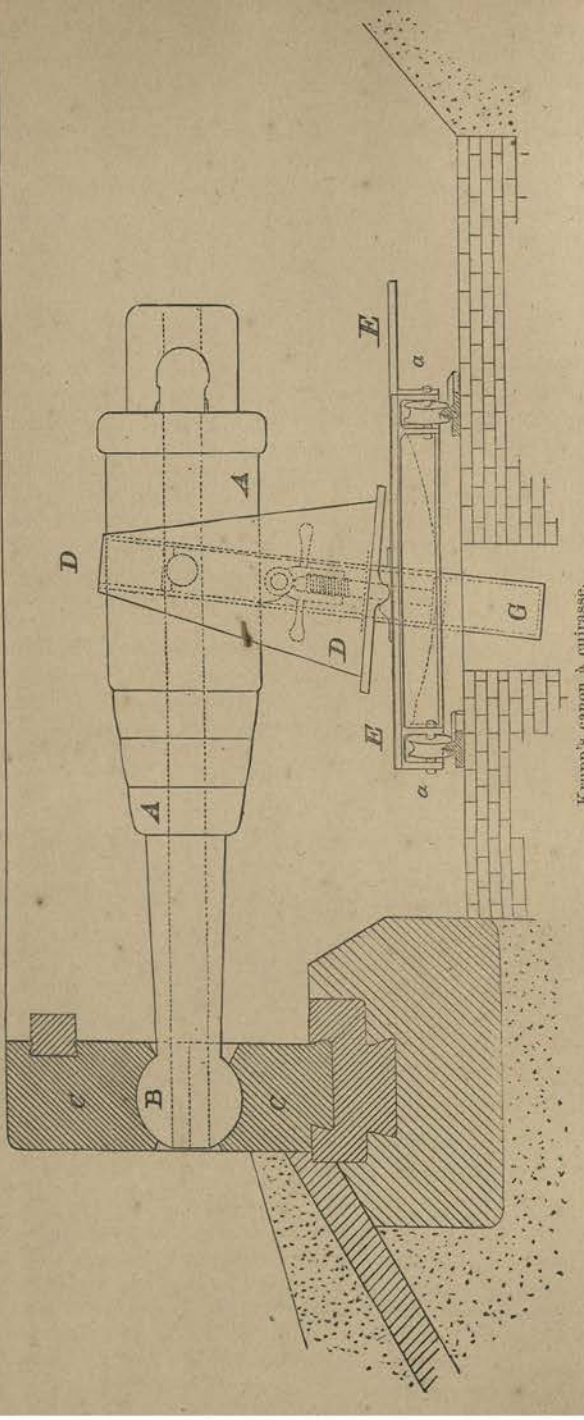
This novel arrangement, invented by Fried Krupp, of Essen, Germany, for the protection of the guns and gunners of a battery, was shown by a model in his exhibit.

It is proposed to build the wall of blocks of forged iron, placed vertically, of a thickness proportionate to the caliber of the gun used, the possibility of constructing blocks of forged iron a meter and a meter and a half thick, enabling a wall to be made of sufficient thickness to withstand the heaviest ordnance. This wall is also braced by inclined struts placed under the tie beam at the top of the shield.

The following description of the canon à cuirasse and its use is taken from a pamphlet written by the inventor:

The "canon à cuirasse" is the same on the whole as the cast-steel cannon of Krupp, being loaded at the breech. This cannon is furnished at its mouth with a spherical protuberance, B, which is fitted in a corresponding space in the muraille-cuirasse C. The pivoting center of the cannon is at the middle of the sphere, and this sphere completely closes the embrasure. This disposition, that is, the union of the cannon and the cuirasse by means of this sphere, permits the movements of the former in all directions. The space behind the wall is sufficient to allow all the necessary vertical and horizontal movements being made.

To maneuver the cannon, it is placed on a gun-carriage, which, having neither to



Krupp's canon à cuirasse.

suffer the shock or lessen the recoil, can be simpler and lighter than the ordinary carriage. The construction of the carriage varies according to its use, whether it is placed behind a *muraille-cuirasse* or in a movable tower, or is for large or small caliber.

For elevating or depressing guns of large caliber, hydraulic apparatus worked by compressed air may be used with advantage. This apparatus is placed under the ground; a simple hand-lever, attached to the carriage, gives the necessary elevation.

The movements of the cannon may also be facilitated by counter-weights or other mechanism of this kind. For guns of small caliber, a rack on the arc of a circle or any elevating apparatus will suffice.

Behind the *muraille-cuirasse* the carriage is given lateral movements by means of wheels fixed on a frame rolling on semi-circular rails. In movable towers the carriage is fixed, the tower giving the lateral movement.

To aim, an apparatus is used fastened to the cannon but placed high enough to be able to see over the *muraille-cuirasse*, or to traverse an opening in covered batteries. To determine the elevation a quadrant may be used.

The pointing is independent of loading, and the two operations can be carried on at the same time.

Cannon *à cuirasse* of large caliber may be employed with advantage for sea-coast defense, and may be constructed of three different kinds, viz, the immovable straight *muraille-cuirasse*, the cuirasse tower, and the cuirasse with its cannon placed on a turning platform behind a second cuirasse, semicircular and fixed, and furnished with a horizontal opening or cut for an embrasure.

The conformation of the coast, and the nature of the navigable waterway, which determines the direction of the advancing ships, are to be considered in selecting the kind of battery to be used.

This system may be applied to batteries already constructed and to guns of small or medium caliber by closing the rear of the embrasure by plates of iron of sufficient thickness to admit the sphere at the mouth of the gun being fitted into it.

The *canon à cuirasse* may also be easily employed on armored vessels when their construction is of sufficient solidity in the parts where they are to be placed to resist the recoil.

No experiments as far as could be ascertained having as yet been made with this cannon *à cuirasse*, it is impossible to form a just appreciation of its value.

BARRACKS.

The only countries presenting the subject of construction of barracks for troops are Russia and Spain; the former exhibiting a series of drawings * with the general directions for their construction, and the latter models of the barracks built near the cities of Madrid and Coruña.

The following translation of the circular issued by the Russian minister of war in 1875 gives a general description of those built for the Russian army:

In August, 1875, the greater part of the Russian army being without barracks of a kind needed by a well organized military force, especially one in which a system of obligatory military service of short terms obtains, the construction of barracks formed an exceedingly necessary want of the country, and the Government was highly desirous of supplying it. As the amount of money necessary for such a purpose was very great, the Government expected to be assisted by the counties and towns which had the greatest interests in having the soldiers quartered in barracks instead of having

* Plate 2 of the series is here inserted.

them distributed in houses and villages. Accordingly the minister of war, to give some idea of the wishes of the Government, caused drawings to be made for infantry and cavalry barracks, these barracks to be built by the city and county governments assisted by the General Government, each paying about one-half of the expenses.

The organization of the grenadier and army regiments with four battalions on peace footing was taken as a basis for this project.

COMPOSITION OF THE REGIMENT.

Staff and field officers	7
Commissioned officers	57
Soldiers and musicians	1,937
Soldiers alone	1,897
Paymaster and clerks	6
Priest	1
Soldiers who do not belong to the file, such as bakers, tailors, &c	106
Horses for officers and transportation	48

STAFF.

Staff or field officers	3
Commissioned officers	5
Paymaster and clerks	6
Priest	1
Clerks and hospital attendants	74
Horses	48

COMPOSITION OF EACH BATTALION.

Field officers	1
Commissioned officers	13
Non-commissioned officers and soldiers	474

Each battalion has four companies, and each company three commissioned officers and 120 non-commissioned officers and soldiers. The company is divided into two platoons, four half platoons, and eight divisions.

The following are the principal ideas that have been adopted for the construction of barracks and the other necessary buildings for quartering a regiment of the above organization.

The officers' quarters must be built near those of their command, and the soldiers' barracks must have near them all the buildings that are necessary for the soldiers' convenience, such as kitchens, store-rooms, ice-houses, &c.

The barracks for the soldiers are to be of brick, two stories high, with an iron roof, the building to be of sufficient size to accommodate one battalion, and must have separate rooms for each company. The kitchen is to be of one story, and built near the battalion barracks. In connection with the kitchens there must be dining-rooms of sufficient size to dine all the battalion at once. Between meal-hours the dinning-rooms are to be used as school-rooms.

The clerks, hospital attendants, carpenters, and smiths are to have a separate building, and in this there is to be a room to be used by the battalion surgeon for receiving the sick at the morning call. Near this building are the workshops, except the smiths' shops, which are separate. The store-rooms, clothing, and ammunition rooms must also be in a separate building.

The regimental-court room is in the same building with the regimental office and guardhouse; in the latter there should be cells for the confinement of prisoners. The officers' dining-room and regimental library are in the house occupied by the unmarried officers. The field officers and those married should have their separate buildings. All the buildings must be far enough from each other to prevent danger of fire. The buildings must be so arranged as to form a square, inclosing sufficient ground for

RUSSIAN BARRACKS.

Plan of Upper Story.

a. Rooms for 428 Enlisted Men.
b. Rooms for 4 1st Sergeants.
c. Rooms for 32 Sergeants.
d. Rooms for 16 Nobility Students.

Plan of Lower Story.

e. Store-Rooms for Soldiers.
f. Vestibule.
g. Stairs and Wash-Rooms.
h. Water-Closets.

regimental drills. The materials to be used are brick and wood, but wood is only to be used for the smaller buildings. The depth of the foundation depends upon the character of the ground and must extend below the action of the frost.

The exterior walls of the brick buildings must not be plastered nor the wooden buildings clapboarded. The roofs are to be either iron, slate, or tiling. The floors in the buildings where men are to live must be of wood, resting on wooden beams. In the bakery and store-rooms they must be of stone or brick, and in the stables of hard clay covered with cobble-stones.

The stoves in the barrack rooms must be of a kind that will assist ventilation as well as warm the building; those in the kitchens and bakeries must help getting rid of the steam and smell. The water-closets are placed close by the barracks, and are ventilated either by the chimneys of the barracks or by special stoves. In the work-rooms, independent of ventilating stoves, such as tailors' rooms and carpenters, &c., a separate stove must be provided. The window frames of the brick buildings are to be double, with six inches between them. The fences are to be of wood and put up only on the front side of the barracks. On the other sides ditches to keep out animals should be made and the earth which is taken out made into mounds upon which shrubbery should be planted.

The plate gives the plan of the first and second stories of the barracks for a battalion of four companies.

BARRACKS OF SPAIN.

The barracks near the city of Madrid are built on the four sides of a rectangle with a wing of the same section as the main building joining the middle of the longer sides, forming two open courts. They accommodate 3,000 officers and men. It is three stories high and two rooms deep and is covered with slate supported by a single-roof truss. It is built of stone and bricks and rests on a foundation of stone.

Though placed upon a hill called "Principe Pio," the foundation was very expensive and cost some $300,000. The barracks were completed in 1864, with a total cost of $1,250,000. The barracks at Coruña are constructed on three sides of a rectangle and are two stories high. They are built of the same materials as the preceding one.

No further description of these barracks will be made, as they do not present any particularly novel features.

FORTIFICATIONS.

The exhibit of Russia contains a relief map of Sevastopol showing the siege and defensive operations of 1854 and 1855 and a description of the defense by General Todtleben, a model of an iron water battery erected for the defense of Cronstadt, and a collection of drawings to be used by military engineers in designing fortifications.

According to these latter, the fortifications are to consist of a series of detached works in defensive relation to each other and placed on a large circumference forming a vast entrenched camp, the forts being armed with heavy ordnance and requiring but small garrisons. These

forts consist of an exterior front, two lateral fronts, and a gorge front. The exterior front is composed of two branches, each making an angle of 70° with the capital. The lateral fronts make an angle of 140° with the exterior front and an angle of 70° with the gorge front.

The line of fire is 115 yards in length for each of the branches of the exterior front, 60 yards for the lateral fronts, and 280 yards for the gorge front.

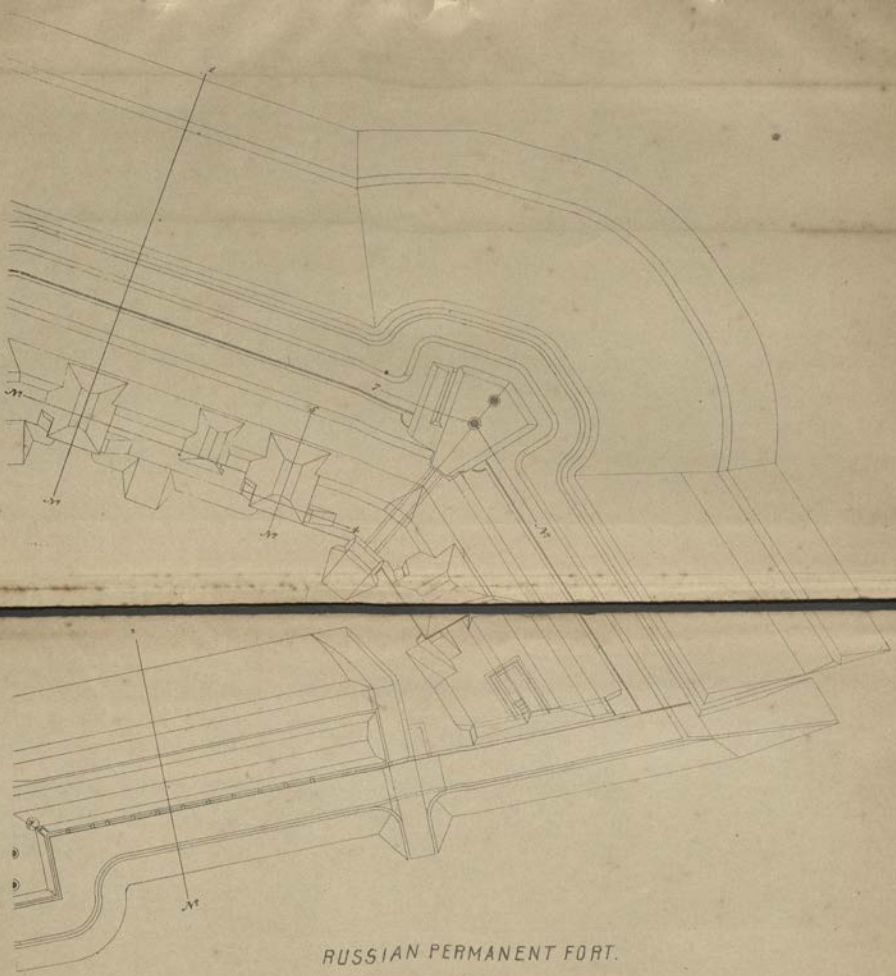
The exterior front is flanked by a caponniére at its salient, the lateral fronts by two half caponniéres placed at their junction with their exterior front, or the three fronts may be flanked by a caponniére placed at each of the latter angles. The gorge front is flanked by a caponniére placed at its middle. A drawing herewith shows one-half of a work flanked in the second manner mentioned.

These flanking caponniéres have one tier of casemates with a battery of four guns on each of their flanking faces, the other faces being pierced for musketry. They are in turn flanked with musketry from the scarp-wall of the work, which is loop-holed in their immediate vicinity. The passage-ways into the caponniére lead from the parade of the work passing under the terre-plein.

On their faces, which are subject to direct or vertical fire, shields are used, which, though they limit the field of fire, prevent but a small portion of the face of the caponniére being exposed. A section of the flanking caponniéres and its shield is shown. These shields may be faced with metal or stone. The plate gives a plan and section showing the arrangements of those constructed with chilled cast iron.

Section No. 1 is a profile section through the exterior front and shows the command and thickness of parapet, width of terre-plein, and depth of the ditches adopted. This also shows the parapet without a scarp-wall, palisading being used instead. Scarp-walls, however, are also used, and they may be detached or semi-detached, but are always fully protected by the glacis. The exterior and lateral fronts are protected from enfilading fire by large traverses placed upon the terre-plein, which extend forward upon the parapet. In these traverses the magazines are placed, as shown in Figs. 2, 3, 4, and 5.

The magazines are of two stories, the first consisting of three rooms, viz, the ante-room, opening upon the parade, the storage-room, and the filling-room. From this latter the ammunition is passed to the terre-plein through an opening next to the parapet on either side of the traverse. The second story consists of one large room extending the length of the three lower ones, and is used as a bomb-proof, the entrance being on either side of the parade end of the traverse. Intermediate traverses are frequently placed upon the terre-plein to divide the distance between the large ones; these are much smaller, and do not extend entirely across the terre-plein. Wooden bomb-proofs are usually constructed in these. Fig. 4, with its section, D E, shows the arrangement of these with the bomb-proof.



RUSSIAN PERMANENT FORT.

General Plan.

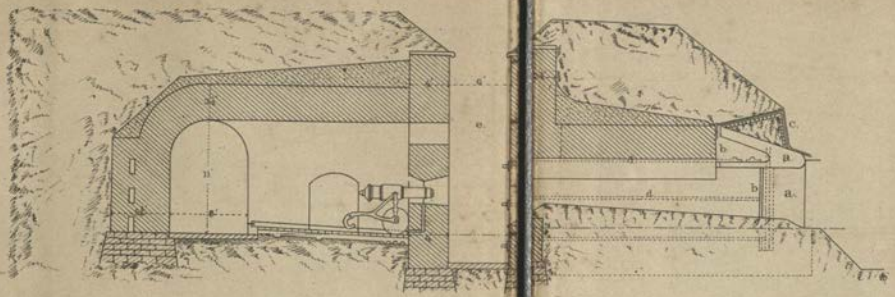
Scale of yards.

Section No. 1.

Section No. 2.

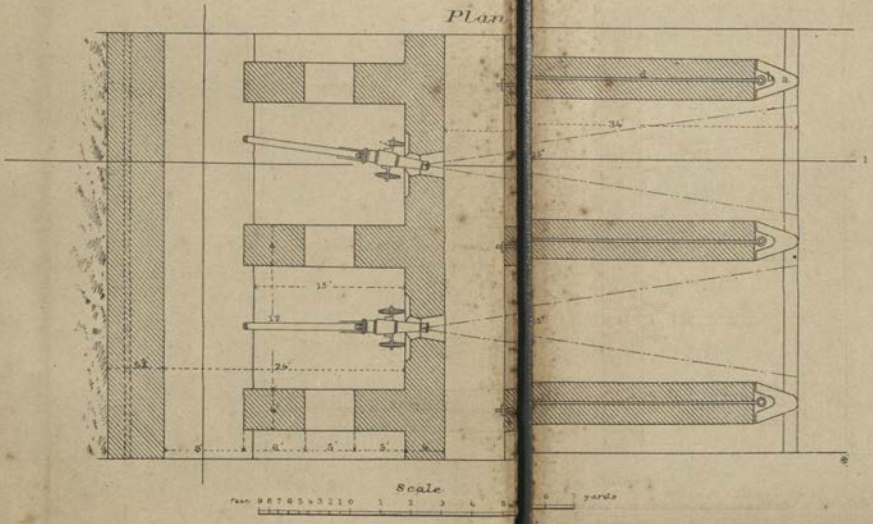
RUSSIAN PERMANENT FORT.

Section No.1

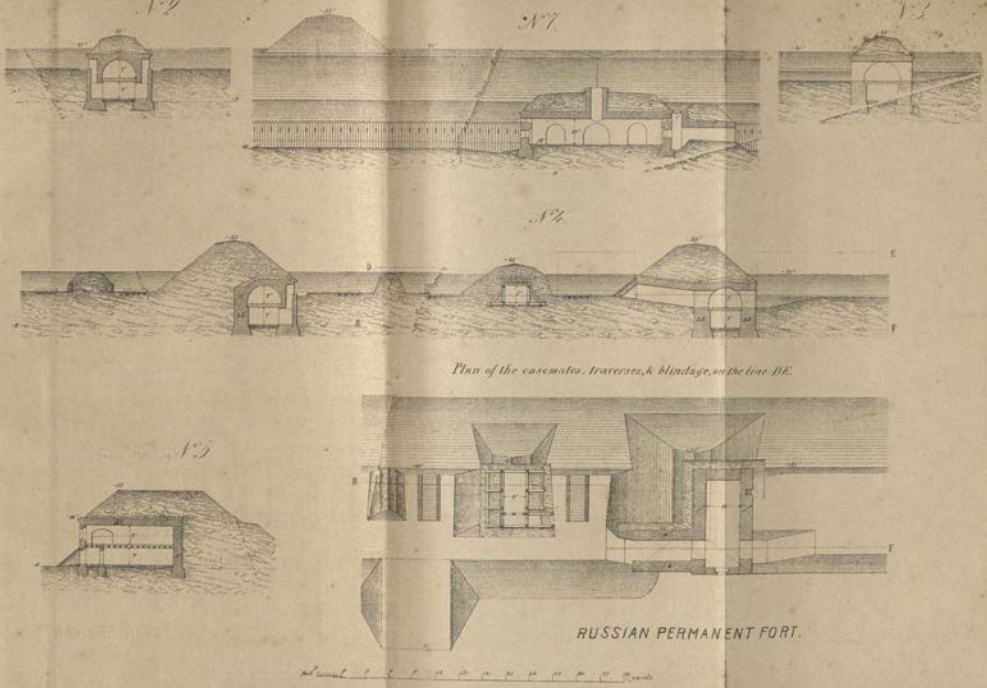


a. Shields faced with Chilled Cast-Iron.
b. Wooden Lining.
c. Iron Earth-Support.
d. Iron Tie.
e. Smoke Hole.

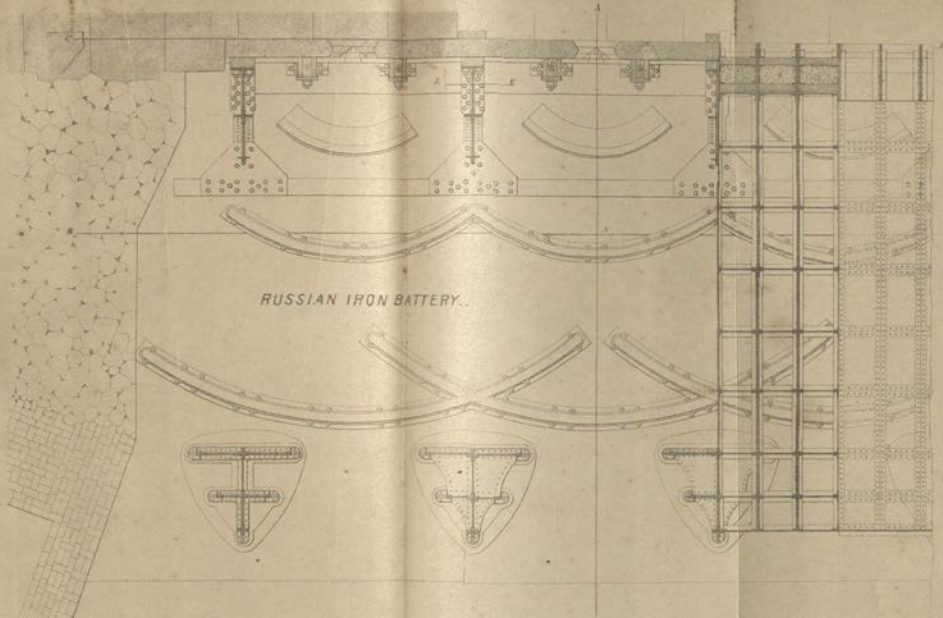
Plan



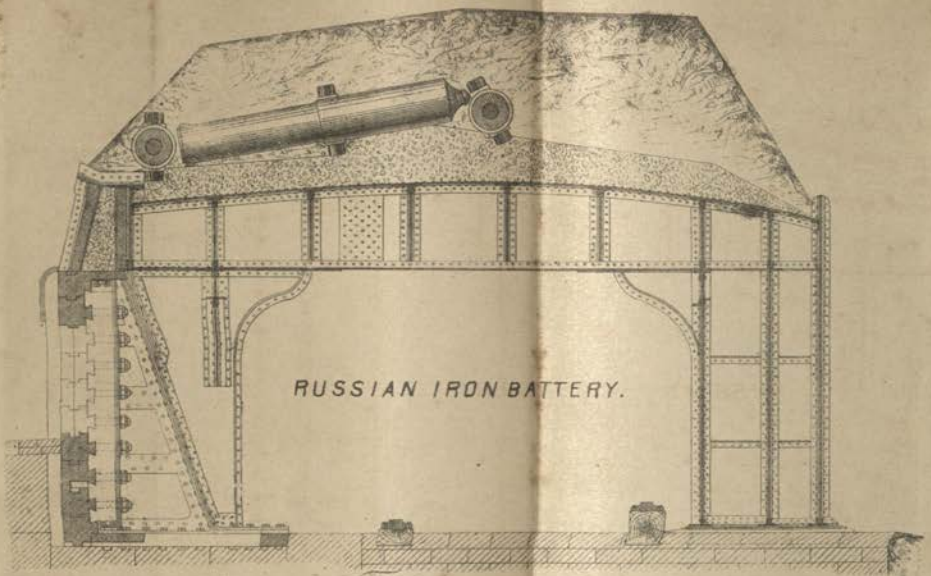
RUSSIAN METAL SHIELDS FOR CAPONN[illegible]ÈRE.


N°2
N°7
N°3
N°4
Plan of the casemates, traverses, & blindage, on the line DE.
N°5
RUSSIAN PERMANENT FORT.

Plate



Section AJ.



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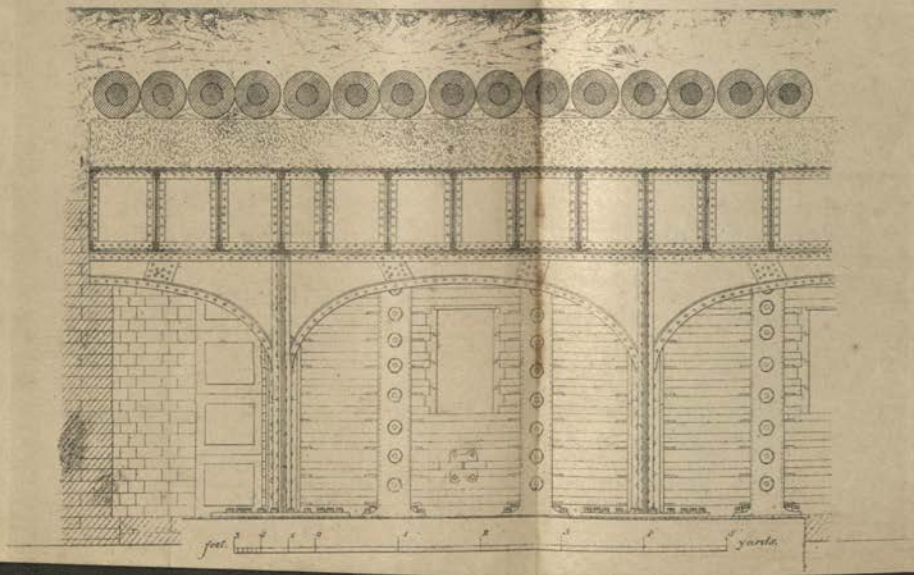
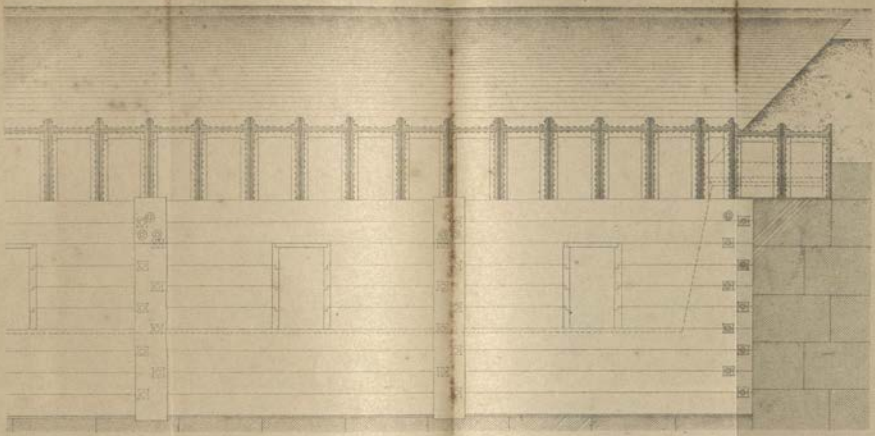
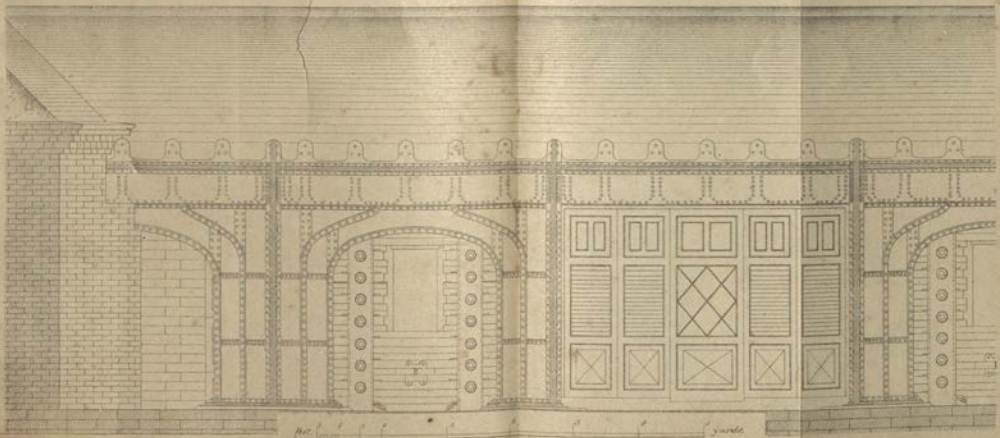


RUSSIAN IRON BATTERY.

Interior elevation.



Exterior elevation.



For quartering the troops barracks are built under the terre-plein of any of the fronts. When the gorge front is used for this purpose, as shown in plate, a face-cover is placed in front of the barracks to protect them from the fire passing over the other fronts. Fig. 6 is a section of these barracks and face-cover. The selection of this front for quarters diminishes considerably the size of the parade, for when the other fronts are used for this purpose the gorge front consists of only a scarp-wall, which may be semi-detached, with an earth cover in rear of it of sufficient size to protect it. At the extremities of this front, where the entrances to the works are usually placed, the scarp-wall is constructed with a gallery behind it and is pierced with loop-holes for musketry, or embrasures for guns. In the latter case a magazine is built behind the gallery, and the position given for it is shown by the dotted lines in the angle between the gorge and lateral front.

Batteries are frequently placed in the coverway, the command of the main work being sufficient to allow the guns of these batteries to be used at the same time as those upon the front in its rear. Traverses are placed between them to prevent enfilade fire. In connection with these batteries, a counter-scarp gallery is built which may be used as a bomb-proof, and behind which the service magazines are placed. The ammunition is raised to the guns from the magazines through openings similar to those used with the service magazines before described for the main work.

Iron shields with iron blindages are also used for sea-coast batteries, the battery at Crondtsadt, before mentioned as being represented by a model, having been built in accordance with the plans adopted for such batteries. There are several different methods given for constructing these shields, but it is not considered necessary to describe them all; the two selected are taken on account of their representative character. For a vertical shield ten rows of iron beams 15 inches thick are dove-tailed together and bolted to a vertical iron frame stiffened by wrought-iron braces. To this shield adjoins an iron bindage composed of a series of iron beams which are covered with iron plating 1 inch thick, and upon this a layer of concrete 1 foot 6 inches thick is placed. On top of the concrete a row of old guns is laid, and these are covered with from 4 to 5 feet of earth. The spaces between the vertical supports at the rear of the blindage are to be left open during peace, but they are closed in case of war. The plates give the plan of this work; a cross and longitudinal section; and an exterior and interior elevation. These show sufficiently the size of the different parts and the manner in which they are put together to make it unnecessary to describe it more fully.

For inclined shields, as, for instance, those making an angle of 75° with the horizontal, the construction of the shield is somewhat changed. In this case it consists of three horizontal rows of iron plates 3 feet wide and 9½ inches thick, with timber lining 6 inches thick, behind which are

placed side by side a series of wrought iron-hollow beams 18 by 18 inches, the whole resting on wrought-iron beams similar to those used in the vertical shield. The entire structure is supported by a foundation of masonry. The blindage used with the inclined shield is constructed in a similar manner as that for the vertical shield.

SPAIN.

The exhibit of Spain contains models of the following works: Castle and fortress of San Juan de Ulloa, built on a sandspit about 1,000 yards from Vera Cruz, Mexico; a round iron tower with three tiers of casemated batteries; a watch-tower of masonry designed for use in Africa by General Arroquia; the plan of Saragossa, showing the earthworks constructed and occupied by the French forces during the siege of that city in 1809; coast-line forts, constructed with concrete made of hydraulic cement and faced with concrete made of lead, to resist armor-plated vessels, by General José Herrera Garcia; plan of the movements and battles of the Spanish forces against the Moors in Morocco in 1859 and 1860, showing their encampments and bases of operation; triangular fort with outside bastion, moat, and circular tower with center; advanced detached work proposed by General Arroquia; a system of fortifications designed by Lieut. Col. Felix Prosperi, and a system designed by General Arroquia.

Beyond the above-mentioned, it is not proposed to describe any of these works, except the systems proposed by Prosperi and Arroquia.

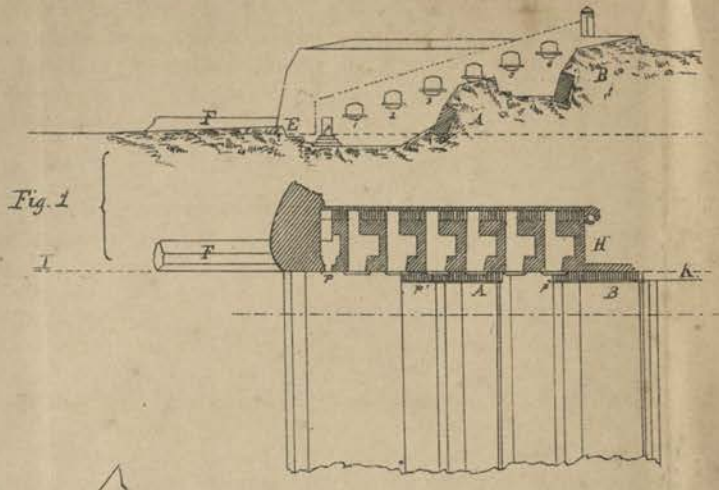
The former system, which is described by Lieut. Col. Emilio Bernaldez, of the Spanish engineers, was proposed by Lieutenant-Colonel Prosperi in 1743, while he was engineer of the Spanish army in Mexico, and was fully described by him in a treatise written at that time. "This system," says Bernaldez, "was so little known, there being only three copies of Prosperi's treatise in existence, and one of these imperfect, that Zastrow in his 'History of Permanent Fortifications' does not even mention his name." This, together with the fact that some of the engineer officers of the German army made inquiries in regard to this system of Bernaldez in 1864, induced him to publish a work describing it in 1868. In this Bernaldez claims that many of the ideas afterward advanced by Montalembert were proposed by Prosperi in his system thirty years before. In speaking of it in his "La Fortification Polygonale," Colonel Brialmont remarks:

> That the first who proposed a rectilinear front with flanking batteries on its capital was Montalembert. Without doubt the mother idea of this tracé is to be found in another work published thirty years before in Mexico by Lieut. Col. Felix Prosperi, of the Spanish engineers, of the existence of which Montalembert was undoubtedly ignorant.

Without any discussion of the claim of Bernaldez, the distinctive features of this system will be stated, as given in the work:

The ditches are wide, the profile strong, the terre-pleins being wider

PROSPERI'S SYSTEM.



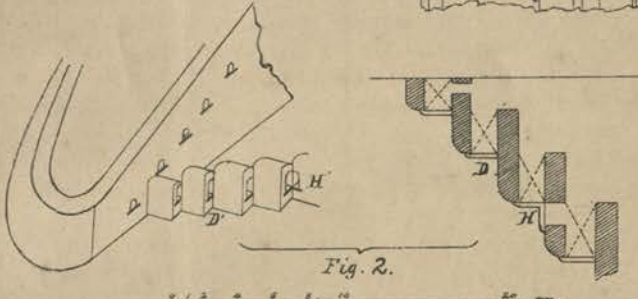


Fig. 2.

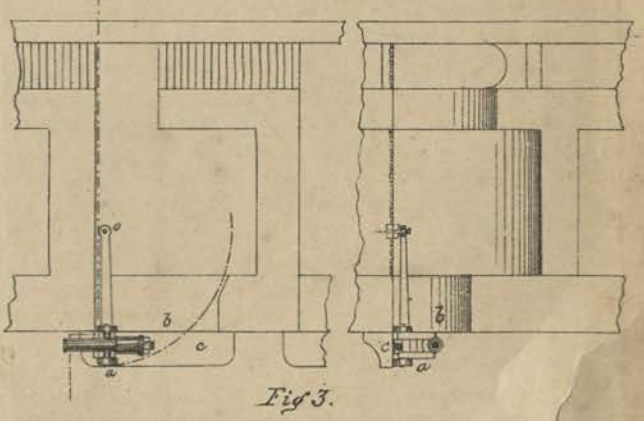
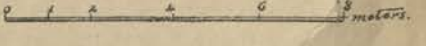
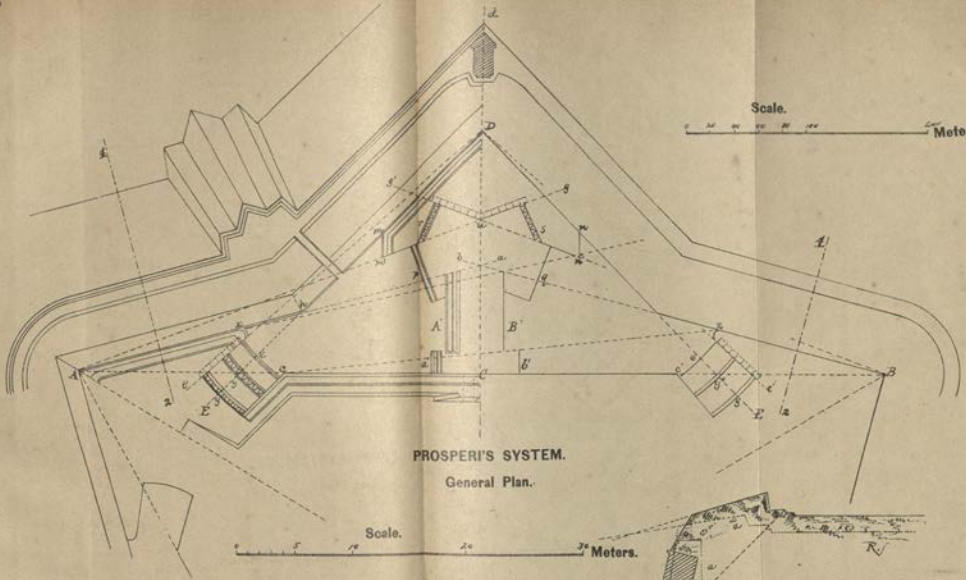


Fig 3.





PROSPERI'S SYSTEM.

General Plan.

Scale.
Meters.

Section 1—2.

and the ramparts higher than any before the present time. (See plate.) The bastions are as large as Choumara afterwards proposed, and the covered way is furnished with a casemated traverse at the salient. The flanks are constructed for three tiers of fire, two of artillery and one of musketry, and are concealed by orillons. There is also a construction called by the author "fijantes," which is an arrangement of casemates by which the guns are loaded under cover and afterwards run out and fired. These casemates are placed in the face of the orillons next to the flank, and on different levels, the floor of each one being on the same level with the top of that immediately preceding it. In front of the door of each casemate there is a platform for the gun to stand upon when fired. By this arrangement all of the guns are fired in the same vertical plane. Fig. 1 shows this arrangement, and Fig. 3 gives the gun when in the casemate and its position for firing.

He also recommends oblique flanks consisting of a series of arched casemates arranged in the manner shown in Fig. 2. For this arrangement, as well as for the "fijantes," he claims the advantage of getting rid of the smoke with great facility.

The ravelins are provided with the same flanking arrangements as the bastions. Iron folding shutters for closing embrasures are also proposed.

In this system there are three orders, the simple, double, and re-enforced order. In the simple order the ravelins are without flanking arrangements and the curtains may be of earth; the bastions, however, are always of masonry. The double order is the one already described, and in the re-enforced order the fronts are provided with face-covers similar to those of many modern works.

ARROQUIA SYSTEM.

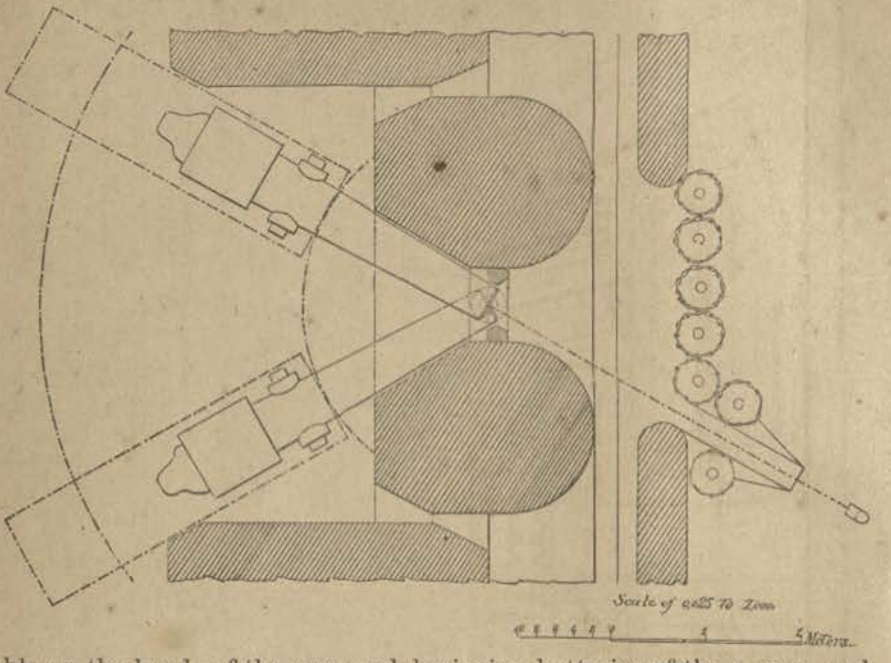
The following synopsis of the work published by General Arroquia, gives some of the reasons why changes are recommended in the present system, as well as describes the one proposed by him:

Arroquia opposes the bastion and the present German polygonal system, because, in the first, all the guns are uncovered and the interior space is too limited, and in the second all of the guns that operate on the field, beyond the enciente, are uncovered, only the artillery of the caponniére and interior redoubt being sufficiently protected. He objects to all outworks because they mask the fire of the enciente without affording an equal protection in preventing bombardment, and would only allow them in extreme cases. He prefers to have enough shelters in the main work to guard against the evil effects of the bombardment, and to effect this proposes extensive casemates, and also makes the walls defensible from the interior. Figs. 1, 2, and 3 show the profile proposed by him.

He also objects to interior redoubts of masonry of the form which are now used, because they are subjected to plunging fire in the beginning

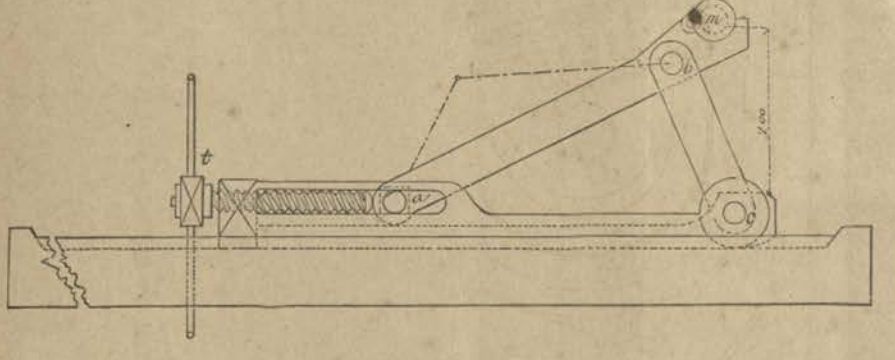
of the siege without being able to return it. Speaking generally, he opposes the placing of one work behind another so as to mask the fire of the one in rear, and he places his so as to have the greatest fire possi-

Fig 4

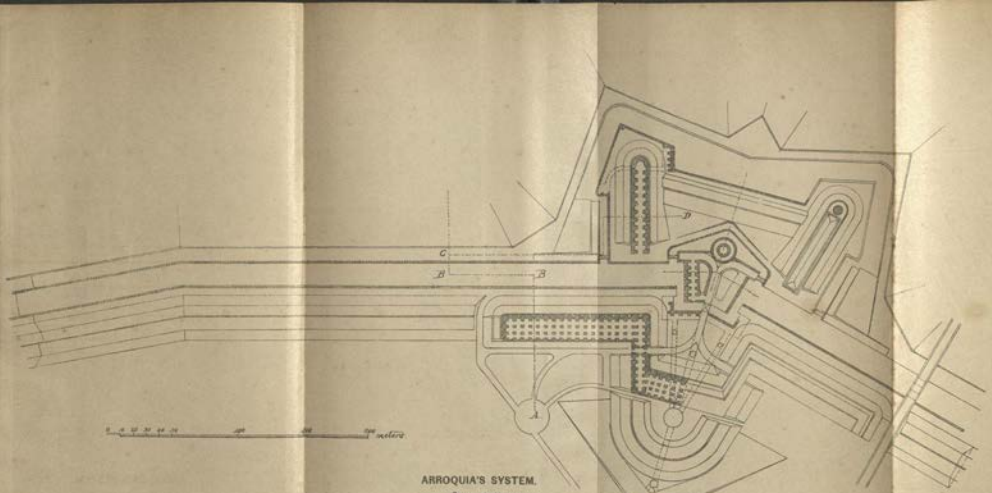


ble on the heads of the saps and besieging batteries of the enemy, and covers all the guns so as not to expose them to fire except from the point they are firing at. This method of protecting the guns is shown in Fig. 4. The embrasures should be only large enough for the muzzle

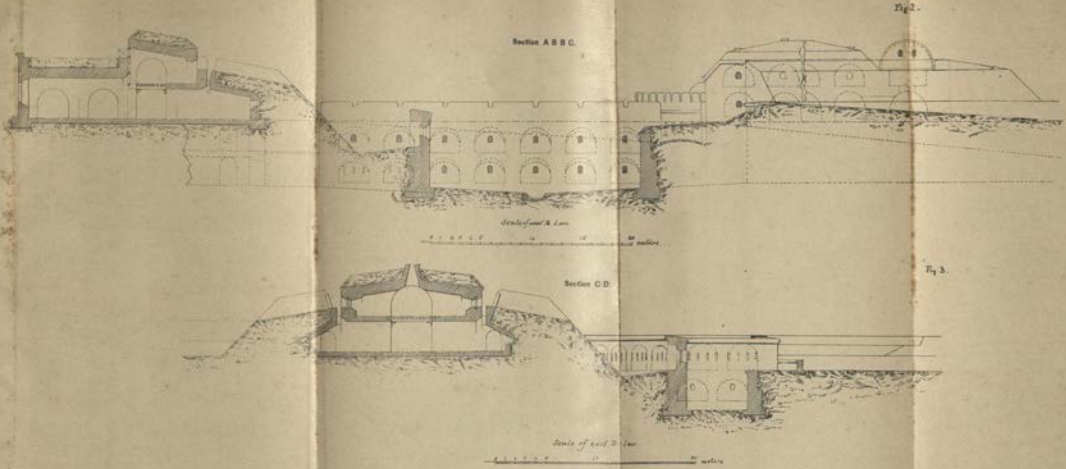
Fig 5



of the piece to pass through. To accomplish this and at the same time admit of the gun being fired at different elevations, he has devised the gun-carriage given in Fig. 5. By turning the screw the whole gun is



ARROQUIA'S SYSTEM.
General Plan.



ARROQUIA'S SYSTEM.

Fig 2.

Section A B B C.

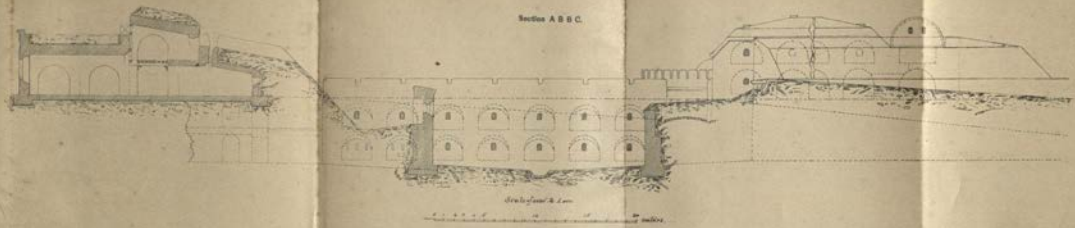
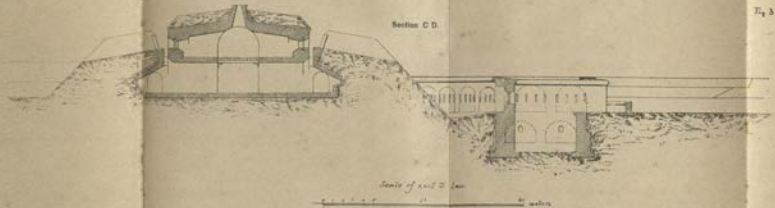


Fig 3.

Section C D.



ARROQUIA'S SYSTEM.

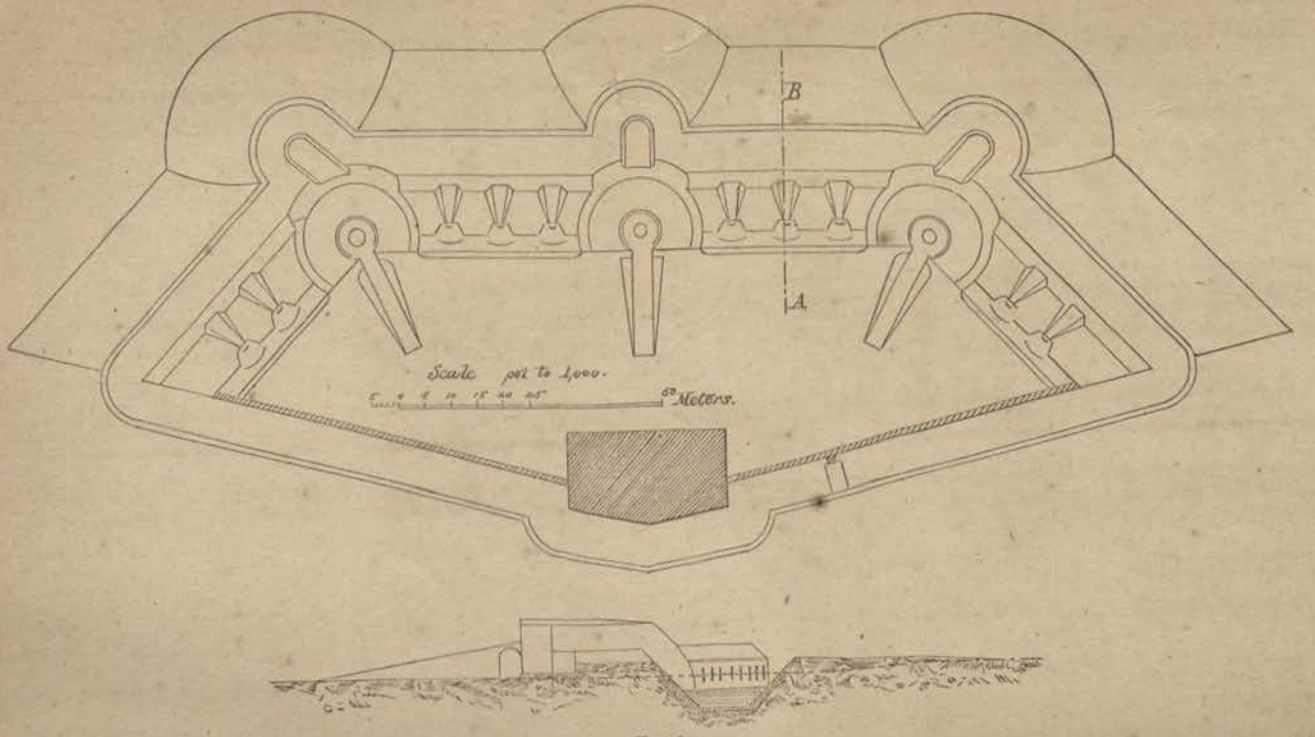


FIG. 6.

raised or lowered, which allows the muzzle to be kept at the same height for all elevations. To protect the fronts of the casemates in a country like Spain, where iron is expensive, he proposes covers of earth and sand.

Arroquia recommends a polygonal system without advanced works, which consists of a general line of retrenchments flanked by caponniéres which sweep the ditch and road. These caponniéres are entirely detached from the main work and are surrounded by strong batteries placed in casemates similiar to those of Haxo and form nuclei for defense. (See Fig. 1.) Large traverses perpendicular to the faces of the main work are placed on each side of the caponniéres and sufficiently in advance of them not to mask their fire sweeping the ditches. These give additional fire upon the field beyond the work and cross-fire in front of the caponniéres. The traverses terminate in an iron tower at their front end, which serves to protect them from an enfiladed fire. (See Fig. 1.) These nuclei are arranged to repel an attack from the rear as well as front.

Arroquia claims for this system a unity of defense, and also that when one of these nuclei is captured the others will have to be taken in succession.

Advanced works are only used when strategical considerations require an intrenched camp. Should they be needed, Arroquia recommends the adoption of those similar to that given on Fig. 6.

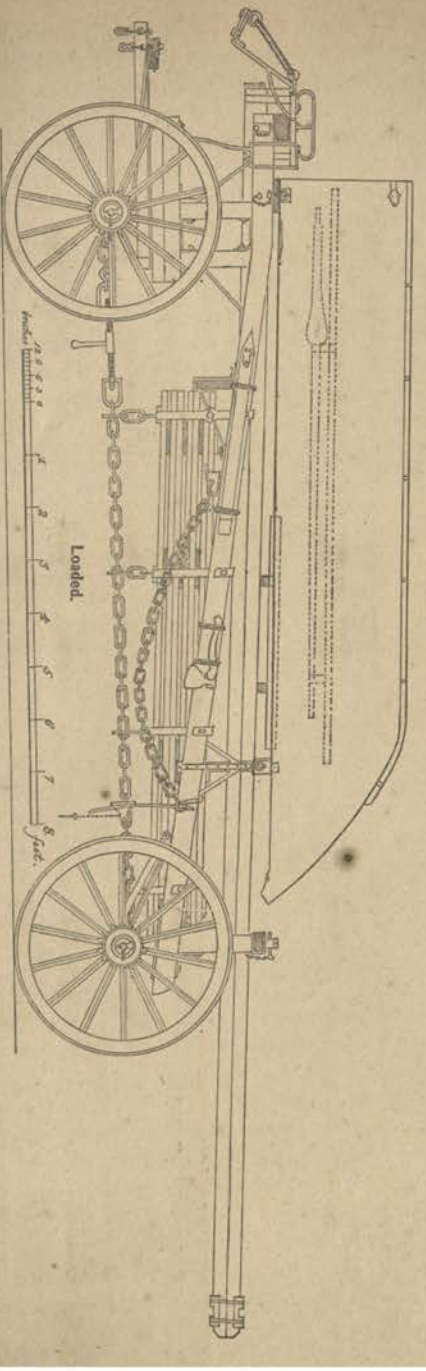
This completes the subject of fortifications as presented by the Exhibition, with the exception of a book, which it might be well to mention here, written by Col. G. A. Van Kirkwigk, of the Netherlands Corps of Engineers, used as part of a course of reading at the Royal Military Academy of that country, and which gives a very complete history of fortifications, commencing with the system proposed by Albrecht Durer, up to the present time.

PONTON EQUIPAGES.

RUSSIAN PONTON EQUIPAGE.

The Russian ponton train (a model of which is exhibited) consists of fifty-eight carriages, two of which are loaded with anchoring boats and the remaining fifty-six, with twenty-eight pontons, eight trestles, and bridge-flooring, balk, &c., for thirty-seven bays, or a bridge of 806 feet in length. The material for two or three bays is always held in reserve, in constructing this bridge, to be used in making repairs. For convenience in maneuvering and using the train, it is divided into four sections, two of fifteen carriages each and two of fourteen each.

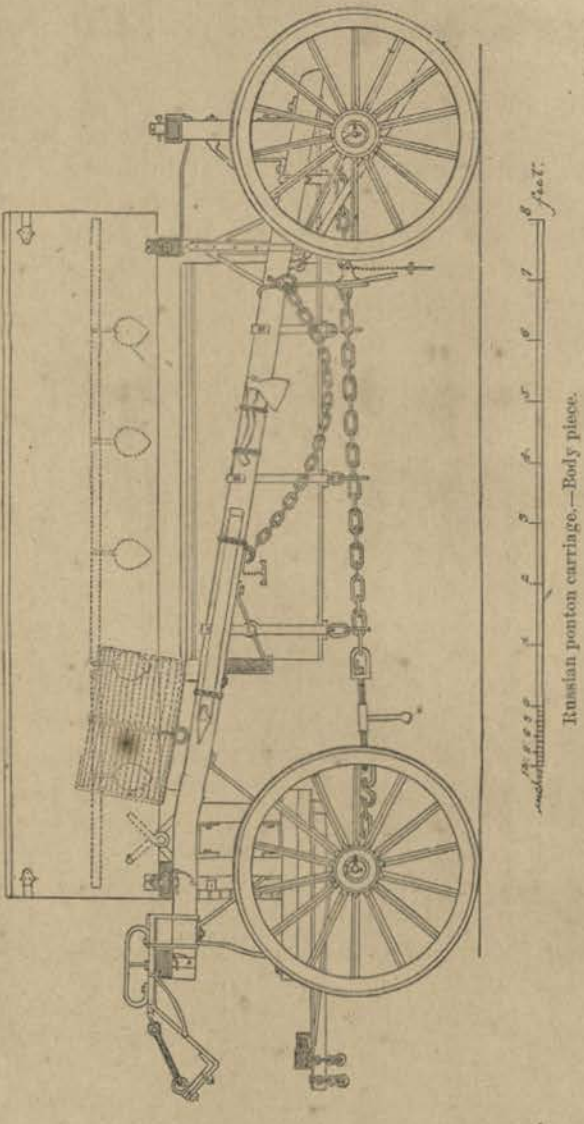
In the ordinary bridge there are five balks to each bay, and a bridge of this kind is sufficiently strong to allow the passage of all kinds of military vehicles except siege-carriages; for these an additional balk



Russian pontoon carriage.—Bow piece.

is added to each bay. When only light loads are to cross, a less number than five balks to each bay is frequently used.

The pontons are flat-bottomed, iron bateaux, and are composed of two pieces fastened together end to end. More than two pieces are used for a single float when it is desired to have a bridge of greater width than 10 feet, the number used being regulated by the width re-



Russian ponton carriage.—Body piece.

quired. The pieces are of two kinds, the bow and the body piece. The body piece is 11 feet 5½ inches in length, and is terminated by vertical planes at its extremities. Its cross-section is uniform and of the shape

of a rectangle with its lower angles rounded. To give greater strength these angles are covered with a sheet of iron which extends about 6 inches on the side and bottom beyond the angle, and is riveted to them. The width of the piece is 6 feet 2¾ inches, and its depth 2 feet 5 inches.

The bow piece, 14 feet 1 inch in length, is terminated at the rear by a vertical plane, and is for 10 feet from this plane of the same uniform cross-section as the body piece. The remaining 4 feet 1 inch diminishes to 3 feet 4 inches in width and to nothing in depth, the extreme end being 4 inches higher than the gunwales of the piece. Each of these pieces are provided with three chafling battens. Their carrying capacity is about 4½ tons and their weight about one-third of a ton.

A ponton always consists of a bow and a body piece or two bow pieces, two body pieces never being used without a bow piece. For bridges of extra width, two bow pieces are always used for the two ends of the float, the increased width being given by placing body pieces between them. When three pieces are used it is called one-and-a-half ponton, and when four, double ponton, &c.

The body piece cannot be navigated alone, and it is only with great difficulty that a bow piece can be. To assist, therefore, in anchoring the ponton two anchoring boats are added to the train. These boats are 20 feet 3 inches long, 5 feet 9 inches beam, and 2 feet 8 inches deep, with sharp bow and stern, and are manned with six oars.

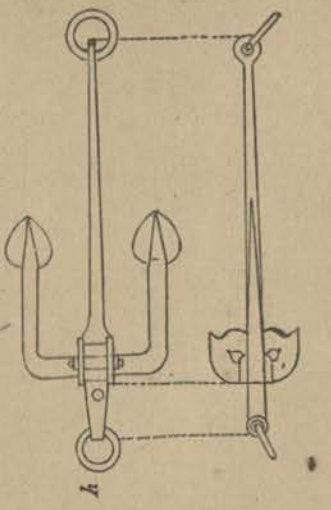
The trestles used are of the pattern designed by Colonel Birago, of the Austrian Imperial Engineers. A full description of the Birago bridge equipage may be found in a work entitled "System of Military Bridges," by Brig. Gen. G. W. Cullum, Colonel Corps of Engineers, U. S. A. There are always twelve sets of legs, four of 8 feet in length, four of 12 feet in length, and four of 16 feet in length, carried with the eight trestle-caps in the train.

The balks, chess, and half-chess are also of the same dimensions as the Birago balks and chess. The balks of two adjoining bays in the bridge meet on a sill directly over the axis of the ponton. Each of these sills rests upon two transoms, which extend across the ponton from side to side, and are fastened to the gunwales.

The carriages are of wood, and are very simple in construction. They are of six kinds, the difference between these being only in the arrangement to carry their respective loads. The following table gives the number of each kind in a train, and their loads:

Kind.	No. of kind.	Loads.
1	32	Half ponton balks and chess.
2	4	Half ponton trestles.
3	12	Half ponton sills, chess, and span wheel.
4	4	Half ponton and smaller articles of the bridge equipment.
5	4	Half ponton and tools.
6	2	Anchoring boats and electrical instruments.

In addition to the above each of these carriages carries the forage of the six horses by which it is drawn. The weight of the unloaded carriage is 1,260 pounds, and from 4,200 to 4,750 pounds loaded.



The anchor used for holding the ponton in position is arranged so as to hold with both flukes at once. The two flukes are attached to the arm which passes through the shank and revolves till it reaches an angle of 60° with it. To remove this anchor a tripping line is attached to the ring *h*. (See figure.)

The bridge is constructed either by successive pontons, by parts, rafts, or by conversion. The trail and flying bridges are also used. For ferrying troops across a stream rafts are made a single bay in length. The proper width to this is given by using two or more pieces of a ponton for each float.

SPANISH PONTON EQUIPAGE.

This train, a model of which is also exhibited, is composed of fifteen carriages, which carry sufficient material for a bridge 55 yards in length and 10 feet in width.

The bridge equipage is the same as that designed by Colonel Birago except the pontons. These are made of steel, and are of about the same dimensions as the wooden bateaux of Birago.

The carriages are of wood and are similar to those of the Russian train, though somewhat heavier. They weigh unloaded 1,600 pounds, and loaded 4,000 pounds. Six mules are used for drawing each of the loaded carriages on the ordinary roads.

SPANISH MOUNTAIN PONTON TRAIN.

This train, which is to accompany a body of light troops, is intended for crossing small streams and ravines in a mountainous country. The

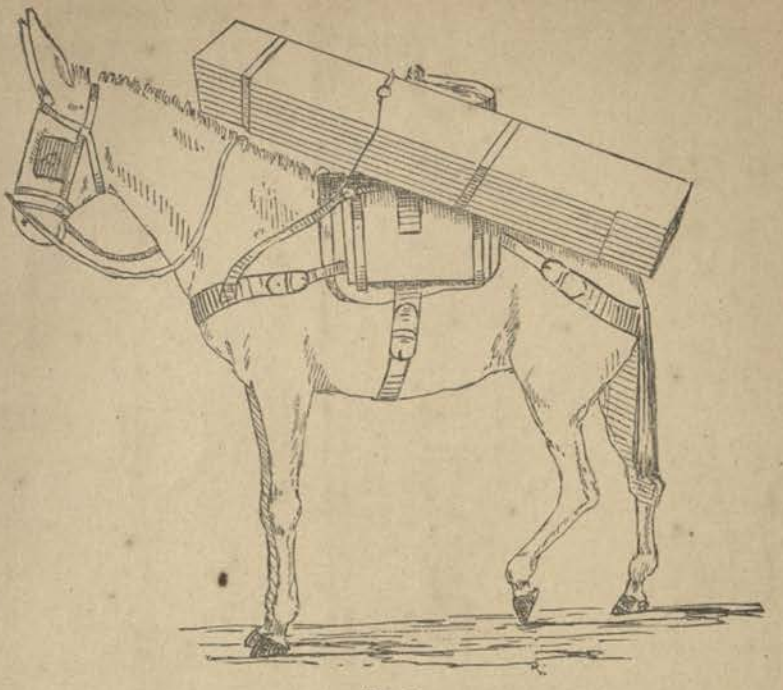


FIG. 1.

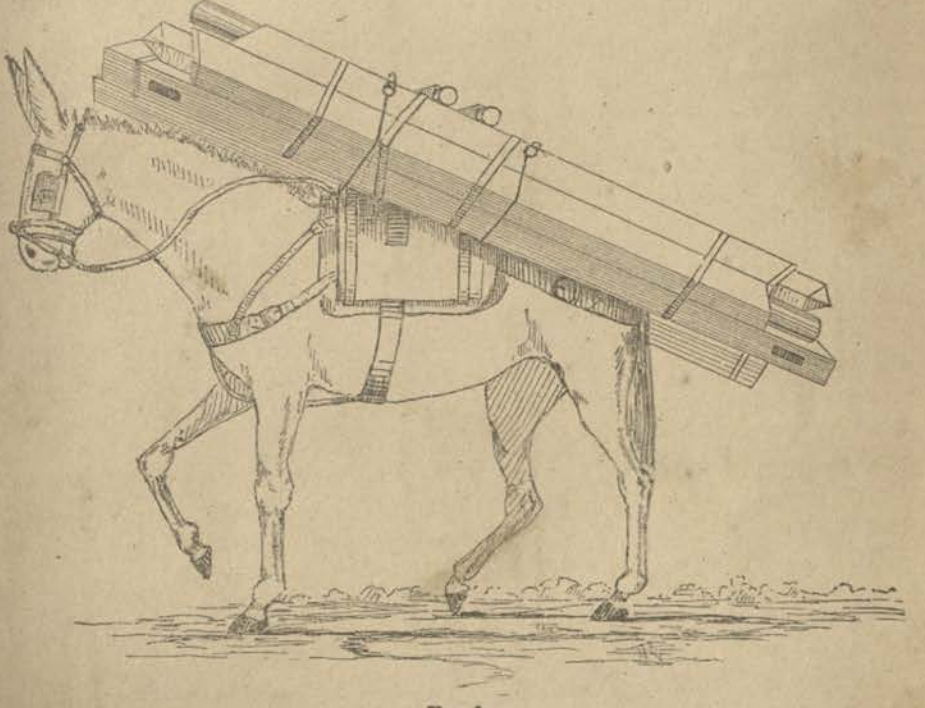


FIG. 2.

FIG. 3.

FIG. 4.

train consists of twenty mules, upon which is loaded material enough for a bridge of 30 yards in length. Figs. 1 and 2 give the method of carrying the material, the load in Fig. 1 consisting of 18 chess and 6 trestles-shoes, and that in Fig. 2 two sets of trestles. These are fastened upon a pack-saddle on the mule in the manner shown in the drawing. It is considered unnecessary to carry balks in this train, as sticks of timber of sufficient size for this purpose may be obtained from the woods of the adjoining country.

Figs. 3 and 4 give the manner of carrying engineer tools for use with advanced troops in a mountainous country. In Fig. 3 an iron frame work is placed upon an ordinary pack-saddle to receive the implements. The load consists of 12 shovels, 14 picks, and 6 adzes. The smaller tools and articles needed are packed in two chests, and these are placed upon the pack-saddle as shown in Fig 4.

SWEDISH PONTON EQUIPAGE.

The ponton equipage now used by the Swedish army (a model of which forms a portion of that country's exhibit) was designed and constructed by Capt. V. Norman, of the Royal Swedish Fortification Corps. The following is taken from the description given by him:

The object of the bridge equipage which has lately been adopted in Sweden has been to remedy several defects which were found in the Swedish bridge equipages, and which are still found in those of some other countries. The principal of these defects are:

1. That the wagons and their loads are too heavy and clumsy.

2. That they are of different kinds, which makes it difficult to exchange an injured wagon for any other wagon of the equipage.

3. That the methods of loading are too complicated.

4. That the connection between the limber and the rear carriage is in most cases very stiff, which causes the wagon often to run on three wheels instead of four when traveling over stones or ditches, instead of following the irregularities of the ground with the requisite flexibility.

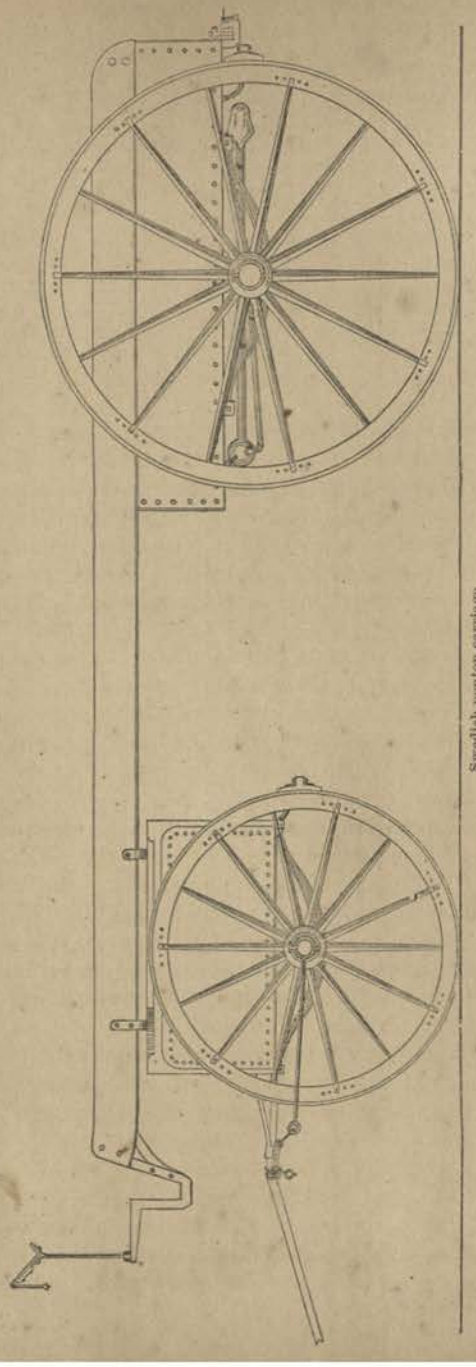
5. That the load is placed too high, which, together with the narrowness of the track, is a frequent cause of upsetting, a defect which must be remedied as far as possible, especially in military wagons, which often have to travel over rough ground.

6. That the carriages, although supposed to admit of being turned anywhere in the shortest possible space, are still, by their own great length and that of the team, difficult to manage in sharp turnings, particularly if gate-posts, ditches, or other impediments limit the space.

7. That, by the system of mounting the draft-horses, the tractile power of these animals is greatly reduced, which unnecessarily increases the number of drivers and horses; that more training is needed for the drivers, and that the difficulty of driving untrained horses, which must frequently occur during a campaign, is considerably increased.

8. That several different sets of harness and methods of attaching the horses, which must not be confused with each other, are used in the same equipage.

9. That the wood used for the wagons and some parts of the bridge has, besides its weight, the inconvenience that the materials, if stored for some length of time, decay and become leaky in the joints, so that the bossing, however carefully it may have



Swedish ponton carriage.

been rimmed, sooner or later begins to loosen in consequence of the raising of the wood and subsequent relaxing of the screws, which causes a friction between these parts and the wood, and finally makes the carriage more rickety and easier to break.

10. That requisite spare parts are wanting, which, after a time, often prevents the perfect use of the equipage.

11. That the utility of the various parts of the train is too limited, which necessitates the use of a greater number and of more patterns than are requisite, and thus increases the weight of the equipage.

12. That the lashings now in use, as well for loading the wagons as in the construction of bridges, are unsuitable and time wasting.

13. That the train wagons of the equipage cannot, in case it should be found expedient to divide the equipage, be properly distributed in sections for carrying provisions, forage, &c.

14. And, finally, the want of cooking wagons, the need of which is being more and more felt, in order to provide the men with warm food at resting places.

Composition of the equipage, and principles of its construction.

The equipage is composed of twenty-eight carriages, of which sixteen are loaded as ponton or plank wagons, eight as trestle or balk wagons, and four as train or forage wagons. These wagons are all precisely alike, and can consequently receive any of the aforesaid loads. The front wheels of the ponton carriage run inside the ponton when loaded, the ponton being carried upside down. This allows the ponton to be lowered over the carriage until its highest point is only 1.66 meters above the ground, hence greater stability is attained.

A self-acting brake is attached to the limber, so constructed that the action of the brake-pads on the wheels is produced by the horses holding back. Thus the brake acts just as much as the occasion requires, and the horses are less strained by the pressure of the carriage. The brake can, by a simple movement, be put out of action, so as not to prevent the backing of the carriage.

Pole-yokes and pole-straps are not used for the purposes of holding back the carriage or moving it to the rear, but the poles end immediately in front of the girths, and are supported by the trace-tugs and by short straps connected with the breeching. By this arrangement the horses are freer in their movement, and the pressure on the shoulder is completely avoided, which, in the hitherto used method of attaching four or six horses, is likely to annoy the wheel-horses.

The wheels of the carriages are of wrought and cast steel, which gives them, with the same strength as wooden ones, a considerably greater durability, besides which a damaged spoke can more easily be replaced by a new one. The wagons are also made of steel, angular or L-shaped steel being preferred.

The maximum weight of a loaded carriage is 1,596 kilograms. By its lesser length—7.43 meters for the bow-piece wagon, 6.83 meters for the body-piece and train wagons, and 9.21 meters for the balk wagon, including the teams—the mobility of the train on uneven ground is increased, the turning in sharp curves is facilitated, the space requisite

for parking, loading, and unloading for bridging in narrow sites is diminished, and, finally, the length of the column is shortened.

The four train wagons in the equipage each contain cooking vessels and one-quarter of the provisions and forage, and they can each be detached to accompany a quarter-equipage. By the use of this cooking apparatus the food only requires to be cooked to somewhat above boiling point, after which the pot is inserted in the appartus, a red-hot heater having previously been put at the bottom of the latter; and, finally, the cover is screwed on. The cooking still goes on, and the food keeps warm twelve hours after being boiled. This is an advantage in a campaign, particularly in rainy weather and heavy marching, when the soldier ought to get his food immediately after arriving at the bivouac, in order to rest afterwards. The labor of the cook and his helps is at the same time diminished, less fuel is needed, and the pots are made to boil in twenty or thirty minutes.

The horses are attached to the carriages of the equipage in teams of three unmounted horses, driven by one driver from the carriage. This method, which has long been in use in the baggage ambulance and some park-wagons of the Swedish artillery and cavalry, has now been adopted also for the bridge equipages. The following calculation indicates the saving in carriages, horses, and drivers attached by using teams of three horses, instead of dividing the same load on carriages with teams of two.

As experience shows a load of 560 kilograms to be a proper one for each horse, a team of two is consequently expected to draw 1,120 kilograms and a team of three, 1,680 kilograms. When, further, an empty wagon weighs about 553 kilograms; a driver and his baggage, 85 kilograms, and one day's rations of oats 8.5 kilograms per horse, the available load of each horse will thus be about 233 kilograms in the double team, and 300 kilograms in the team of three. If, therefore, a net load of say 25,200 kilograms is to be carried, it will require by teams of two 52 wagons, 54 drivers, and 108 horses, and by teams of three, 28 wagons, 28 drivers, and 84 horses. This shows also that a column of carriages drawn by teams of three occupies little more than half the length of a column of carriages drawn by double teams, each column carrying the same weight.

Advantage is also claimed for teams of three over those of four or eight, in which inconvenience sometimes occurs by horses of different strength, endurance, and action being coupled together. The swingtrees of the carriages are attached to fixed cross-hounds, and the horses are made as independent of each other as possible; even if only one horse should draw, the greater part of the tractile force would still move the carriage onward, and only a small component of it act on turning the carriage, which latter force would moreover be partly counteracted by the pole. A weaker horse can, therefore, if necessary, be spared with-

out any other inconvenience resulting than a slight side-pressure. This is not the case in the latter teams. It is also easier to reinforce a team of three than one of four or eight, as, in the former, one spare horse can easily and advantageously be added in front, while for this latter not less than a pair would be of use. With this wagon and team the horses are not so often exposed to tread on or over the traces, as the cross-hound and the swing-trees are pushed back when the carriage is held back.

Detailed description of the carriage.

The body of the carriage consists of the side-rails, which at the front and in the rear are bent down, forming angles to support the ponton and the binder of a large rear box, and of a smaller one for the limber, and of two foot-boards. The side-rails, of L-shaped steel, are connected with each other by three transoms, also of steel, and are on the outside strengthened by a pine board, the upper edge of which is covered with iron, while the projecting inside edge of the side-rails is left free to support cases, boxes, &c. On the sides there are six side-rail rings for fastening boxes, lashings, &c. At the rear end two vertically descending braces are riveted, each of which ends in a stirrup, formed by the bending of the steel in a double angle, intended for supporting the binder, hanging spare wheels, &c. The binder is kept in place by fastenings attached to each brace. These braces are connected by a transom, to the under side of which the anchor-chains are attached.

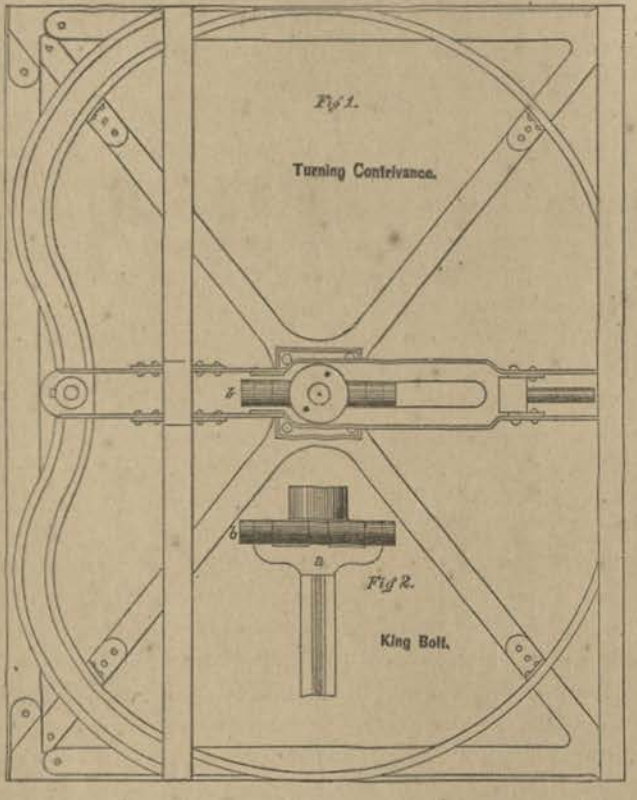
The rear box of the carriage consists of L-shaped steels and sides of iron plate, is in front fixed to the side-rails and behind fastened to the aforenamed stirrups, and steadied on the inside of the plates by vertical braces descending from the side-rails to the ends of the springs, as well as by slender wooden binders between the vertical braces. The front of the box is closed by a door of iron plate in an iron frame, moving on hinges at its base and fastened by padlocks and two overfalls affixed at the front suspending-brace of the box. The loose hind part of the floor of the box, which is of wood, with two narrow binding-irons underneath, is supported by the floor-iron of the box. It can be pulled out backwards and has a tail-board on hinges, which is shut by a hook and its key. There is a ring and a loop at the front corners of the box for fastening the resting-chain of the anchor.

A track formed by two L-shaped steel bars runs over the midst of the limber and is fastened to the first two transoms. These are connected at their front extremities by a plate of steel, in which a bolt projecting below the plate is fastened. The track thus formed, upon which the head of the king-bolt rests, moves forward when the carriage is turned. (See Fig. 1.)

At the extremity of the bolt projecting below the connecting-plate above mentioned, a washer is placed which runs in a track formed by

two L-shaped pieces of steel, the base being turned upwards to confine the washer. This track is fastened to four radial arms of steel, the shape of it being such that the track for the king-bolt head advances 0.2 meter whenever the limber is turned.

The king-bolt is firmly secured to the intersection of the four radial arms and is of the shape given in the drawing (Fig. 2), and has a joint at *a*, formed by three ears from the lower part and two from the upper,



through which the bolt *b* passes. The lower part of it extends in to the middle of the limber-chest, and is confined by four vertical braces, between which it slides.

When the road is even or smooth the rectangular frame given in the drawing, and which connects the extremities of the radial arm, rests upon the top of the limber chest, but when either of the wheels is raised by the unevenness of the ground, the tipping of the limber raises the frame with both tracks and king-bolt vertically, the latter sliding between the four vertical braces in the chest, the joint, at the same time, relieving the strain by enabling the frame to remain horizontal.

The limber-box rests directly upon the springs, and consists of one upper and one lower rectangular frame of L-steel connected by four vertical braces, the ends of which are bent and fastened to the sides of the

frames. In the middle of the box four slender L-shaped braces bent into two right angles and riveted to the frames of the box, as well as to the upper and lower plates, form a track for the lower part of the king-bolt to move in. At the back of the box there are two steel doors framed in steel, and in the middle a hook for the water-bucket. The sides of the box are covered by thin plates, riveted to the frames. Two L-shaped apertures have been filed in the bottom of the carriage, which admit of the hounds being pushed back into the box up to the middle of the axle. The passages are protected by plates folded over them, so that the hounds can easily move forwards and backwards. These plates are fastened to the under frame of the box.

A round iron riveted to the middle of the fore cross-hound runs back from it through a canal formed by the upper edges of the under frame of the box, ending in a harp-shaped hook, with a screw and nut for the levers of the brake-pads. These latter are of steel, and have ears, in which the lever-arms are fastened. There is also a brake-pad behind the left rear wheel, but this is tightened by a screw placed under one of the descending stirrups of the side rails.

To prevent the pushing back of the fore cross-hound and the stopping of the carriage by the brake, two stopping-arms have been affixed to the front of the limber. These arms are connected with each other by a slender wooden binder and are raised by hooks.

From the front of the side rails steel braces similar to those at the rear, but making an obtuse angle with the side rails, descend, forming here, likewise, a stirrup, though somewhat higher than the one at the rear, and being afterwards bent in a right angle to form a rest for the lower footboard. The stirrups are supported by arched flat-irons, running up to the side rails and by traverse braces of round iron. They have movable noses for the securing of the pontons.

The upper footboard is secured to the body of the carriage by the round irons riveted to the bottom of the upper footboard, the ends of which descend into metal pockets on the rest of the lower footboard. This latter has loops and rings for the securing of axes, spades, &c., and eight dowels for the balks. To steady itself the upper footboard has hooking braces, which can be hooked either in the forward boat-rings of the ponton or the front pack-case, if the carriage be used as a baggage-wagon. When the carriage is empty this upper footboard is also used as a box for the driver. To this end, holes are made in the side rails in which the ends of the round irons are put. The requisite inclination is secured by two movable supports fastened to the front transom of the side rails and running into holes on the under side of the footboard.

An L shaped steel and a slender wooden binder, which are both connected by hinges with the rear transom of the side rails, form a bolster for the object of keeping the chesses in place, and prevent them or the rear pack-case from sliding backwards. To support the chesses, both the steel and the binder are opened over the transom, but to support a

pack-case only the steel one is opened. When balks are carried both remain down. In order to prevent the chesses from sliding forwards, there are also two other wooden bolsters connected by hinges with the front transom of the side rails. These can be put down when pack-cases or balks are carried.

The springs, six-leaved and 0.74 meter in length, are placed under the axle-tree, to which they are fastened by plates. The front end of the upper leaf is shaped into a hinge, moving around a bolt underneath the front brace at the end of the front braces. The rear end, which is strengthened by an additional plate, slides under a stirrup, which (on the limber) descends from the rear corner of the box and is prolonged backwards to form a support for the lever-arms of the brakes.

The axles are square above the spring, octagonal further in, and round in the middle, but cylindrical in the hubs.

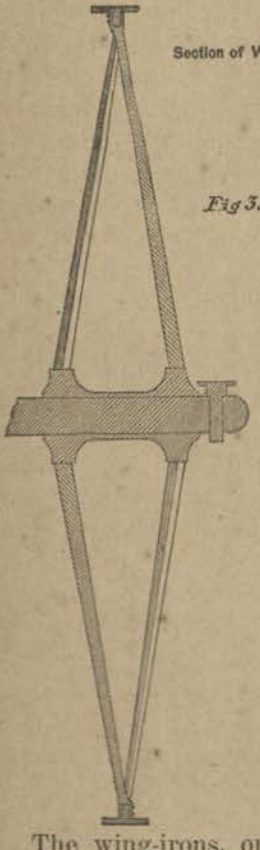


Fig 3.

The hub (Fig. 3) is of cast steel and has no separate box. In case of great wear, however, a box of iron or other metal can be affixed. The spokes, of which the front wheels have ten and the rear wheels fourteen, are of square steel, screwed into the hub and fastened to the felloe by two blades, of which one is merely folded over, but the other fixed by four rivets. The holes made in the hub for screwing in the spokes do not extend through. The diameter of the worms is larger than the diagonal of the spokes. A steel plate, with a screw, forms a hood round the hub between the spokes, to receive the greasing. The felloe is of T shaped steel.

The appurtenances.

The lashings of 12-ply ropes are 18 feet long, having one end formed into an eye and the other whipped to prevent raveling. Weight, 0.95 pound. The bolts of the poles or shafts, are of round iron, 2 feet 6 inches long, bent in angle at one end, and with a hole for the pin in the other. Weight, 2 pounds.

The foot-board has already been discribed in connection with the carriage.

The wing-irons, or wings of round iron, are fixed to the upper pack-case by supports descending into pockets at the side of the box. The upper part of the wing is bent out, so as to afford a rest for the arm of the driver. Height over the box, 56 inches; breadth behind, 1.5 feet; weight, 2.75 pounds.

The pack-cases of pine are 3.54 feet long, 1.82 feet wide, and 1.35 feet

deep, encircled by a thin iron-plate lining. The sides are 0.4 inch thick, the bottom and the top, 0.7 inch. On each side there are a hasp for a padlock, a handle to which the straps are fastened, and two pockets for the supports of the wing. The top is connected with the box by three hinges, and can be opened while the case is on the carriage. The sides of the top are lined with plates, the edges of which fold over and fit into a small groove cut in the side of the box. The top is covered by painted canvas. Weight, 50 pounds.

The tarpaulins of the rear box of the carriage are made so large that they completely cover its floor and fold over the sides. Weight, 5 pounds. The weight of the padlocks is 0.50 pound. The tar-buckets weigh 0.75 pound. The straps, with their hooks, weigh 0.85 pound.

The swing-trees have movable shutting clasps to the hooks. The sides of the loops are made straight instead of bent. Weight, 3 pounds.

The poles, of birch-wood, are 2 inches thick, 8.45 feet long excluding, and 8.75 feet including, the loop. An iron cylinder is fastened at a right angle to the rear end of the pole by riveted plates. At the front end there is a loop and a rectangular eye for the straps. Weight, 23 pounds.

The water-buckets, 9 inches deep, with an inner diameter of 8 inches at the top and 7 inches at the bottom, are made of iron plate and strengthened by a thick steel wire around the upper edge, and another around the bottom. They have a handle of thick steel wire and a suspension shoe on the side. Weight, 65 pounds.

The bridge equipments.

The anchors.—Distance between the fluke ends, 3.08 feet; length of the shank, 4.46 feet; thickness at the lower ends, 1.4 feet, and at the upper, 1.1 feet. Outer diameter of the ring, 4.20 inches; inner diameter, 3.4 inches. Breadth of the flukes, 6 inches. The thicker square iron around the hole of the shank, 2 inches square. Length of the arms of the fluke, 3.43 feet; diameter of the ends, 6 inches; at the middle, 1 inch; diameter of the stop on the stock, 1.7 inches. Weight, 120 to 126 pounds.

The grapple.—Maximum length 2.1 feet; lower diameter of the body at the junction of the arms, 1.1 feet; upper diameter, 0.7 inch; diameter of the arms, 0.7 inch; outer diameter of the ring, 2.4 inches; inner diameter, 1.8 inches; distance between the arms, 1.25 feet. Weight, 14 pounds.

The anchor cable is 240 feet long, 2.5 inches in diameter; weight, 82 pounds.

The trestle-legs are of two lengths, 9 and 14 feet respectively. The longer ones can also be used as abutment sills, and the shorter ones as balk-saddles. They are made of pine and of the same dimensions as the balks (5.4 by 4 inches). At both ends they have square dowels, of which

one is encircled by a band and cap of iron plate, and the other by a band and a shoe with a hole for the toggle. At each end of the leg there is also a hole for the bolt of the binder of the carriage. Weight of the longer leg, 85 pounds; weight of the shorter, 55 pounds.

The trestle-cap is of pine (5.4 inches broad and 7 inches high) and has at each end an iron plate mortice for the legs.

The shoe of the trestle is made of two thicknesses of spruce plank, dovetailed together, their grains running contrary, encircled by iron rings. It has a square hole in the middle, lined with iron, and so made that the trestle-leg can move in both directions, and at one end a chain with a toggle.

The jack is the same as used heretofore. Weight, 45 pounds.

The towing ropes 60 feet long, of 18-ply rope, and whipped at both ends. Weight, 7.66 pounds.

The chesses, 10 inches wide, 1.46 inches thick, and 11 feet long, are composed of two spruce boards dovetailed together. A piece, 1.5 feet long and 0.8 inch wide, is taken out at each side for the passage of the lashings. Weight, 50 pounds.

The half-chess is the half of a chess, but without any dovetails; it has two holes for the lashings. Weight, 25 pounds.

The suspension chain is 7 feet long, not including the ring belonging to one of its ends. This ring is to be put around the top of the trestle-leg.

The guard-ropes are like the towing-ropes, but only 30 feet long. Weight, 8 pounds.

The ponton bow-piece, 13.7 feet long, 6.4 feet wide, and 2.69 feet deep outwardly, has a skeleton of L-shaped steel frames, 1.041 by 1.041 inches by 0.104 inch, of which eight are transoms, two support the partition, and one the bow. Between these frames the sides are covered with iron plates of 0.052 inch thickness, and the bottom by plates 0.078 inch. The gunwale of L-steel, 1.25 by 1.041 inches by 0.078 inch. The ponton has 9.9 feet long chafing-battens of spruce, 1.4 by 2 inches in section. These are rounded at the ends and fastened by small plates bent in a right angle and riveted to the transoms.

The partition is straight, and connects at right angles with the sides and the bottom. The bow is slightly pointed, and curves upwards. The connection between the bottom and the sides is rounded; the bottom plates, which are riveted together at the middle of the ponton, running up higher than the rounding.

Two round shoes are fastened to the bow, immediately in front of the first transom—one by rivets and the other by bolts and heads. These shoes support the mooring-brace, which moves in them.

To connect the forward and the stern ponton, each ponton has a hook-bolt passing through the partition, having a crank with a movable closing hook, which, when the crank is being turned, catches in a ratchet on a plate riveted to the partition. The hook-bolt passes through this

plate, and around the hole there is an inclined surface, by means of which the grip of the hook is tightened when the crank is turned. At the other end of the partition there is a rectangular perforation of the gunwale to admit the hook-bolt of the other ponton, and at the inner side an extra plate is riveted around it. To connect the pontons at the bottom a loop-bolt is riveted to one of the outsides, at the last transom. A chain with a connection-fork descends from this loop-bolt. There is also fastened to each outside, near the partition, a packet, in which one of the arms of the aforesaid fork fits. Weight of the bow-piece, 920 pounds.

The body-piece, 11.7 feet long, of the same width and depth as the bow-piece, and having the same section dimensions and the same kinds of steel and plate, two vertical braces, with lashing hooks, running at right angles with the sides; chafing-battens along the whole length of the bottom; longitudinal braces through the whole sides; hook-bolts and connecting-forks at opposite corners of the partition; four mast-shoes, and two forks for the carriage-binders. Weight, 910 pounds.

The movable cleat is very nearly like the one lately adopted in Austria. Weight, 10 pounds.

The wedge is of oak, 1.5 feet long, 3.75 inches wide, and 1.6 inches thick at the top, and 0.3 inch at the edge. Weight, 1 pound.

The lashings, 15 feet long, of 15-ply rope, have one end formed into an eye and the other whipped. Weight, 0.5 pound.

The bolster is of spruce, and has on one side two movable bolts, which fit into the rowlocks on the partition of the ponton. Weight, 9.50 pounds.

The balk-binder, 6.4 feet long, 4 inches thick, and 3 inches thick, of spruce, has in its middle a dowel for fastening the abutment sill of a bridge, and an arm which is movable around the dowel, with a ring for the oar when used as a support to guard-ropes. Each end of the binder has a movable hook for securing the ponton, &c. Weight, 48.25 pounds.

The balks of pine, 20.76 feet long, 5.4 inches thick, and 4 inches broad, have a cleat of thick iron plate at each end, and an iron shoe, forming an eye, riveted over the cleat for the lashings. Distance from the middle of one cleat to the middle of the other, 20 feet. Weight, 138 pounds.

The oars are of pine, and have the grip end shod with iron. This shoe is encircled by an iron ring with ears, through which passes a bolt for the rowlock. The oar-blade is sheathed with iron plate at its extremity. Weight, 13 pounds.

The side-rails are pine beams 3.5 by 3 inches, and have two holes for the lashings. Weight, 75 pounds.

General description of the loading.

1. Each ponton-wagon carries 1 ponton-section, 1 mooring-cable or 1 anchor, 15 chesses, 4 half-chesses, 1 saddle (short trestle leg), lashings, &c.

2. The balk-wagons carry 8 balks, 1 trestle-cap, 2 long trestle-legs, 2 suspension-chains, 2 trestle-shoes, 3 side-rails, 4 pickets, 1 maul, lashings, &c.

3. The train and forage wagons are loaded on two plans, No. 1 and No. 2. The two wagons No. 1 carry painters', saddlers', smiths', carpenters', and earth-works tools, as well as their requisite spare parts, and raw material, besides spare parts for the harness and carriage, veterinary instruments, light, and cooking apparatus, &c.

The two wagons No. 2 carry smiths' tools and stores, spare parts of the appurtenances and bridging equipments, material, stores, and baggage.

Each of the train wagons carries, besides, 1 maul, 1 scythe, 1 forage-measure, nose-bags, and grooming implements for the spare horses, 4 days' rations for 25 men, cooking pots for one meal for the same number, and forage for one-quarter equipage (25 horses).

4. Each wagon of the equipage has also ropes and pickets, 2 spades, 1 ax, horseshoes, rivets, &c.

The equipage can be divided into one-half and one-fourth equipage, and the ponton wagons separately into one-eighth equipage.

Each equipage carries 8 supports, of two ponton-sections each, and a like number of trestle supports, 240 chesses, and 64 balks, with the necessary wedges, lashings, &c. This material will construct a bridge with 5 balks to each bay of 240 feet in length, with 4 balks to the bay and a roadway 7½ fee 20 feet, and 3 balks to the bay and roadway 5 feet wide, 477 feet in length.

UNITED STATES PONTON EQUIPAGE.

The ponton equipage used in the United States service, and which forms a part of the exhibit of the Corps of Engineers, United States Army, is composed of reserve and of advance guard trains.

These trains were adopted in 1869 for the Engineer service of the Army, upon a report of a Board of Engineer Officers convened for the purpose of reporting upon the construction and organization of bridge trains for the Armies of the United States, and who, after a thorough study of the ponton equipage of the European nations, together with the experiences of such trains as were used during the late war of the rebellion, finally recommended the present organization.

Reserve train equipage.

This equipage is divided into trains of five divisions each, four of which are ponton divisions and one supply division. Each division is accompanied by one tool wagon and one forge.

The ponton divisions are complete in themselves, and each contains sufficient material for eleven bays, or a bridge 255 feet in length.

Each of these divisions is subdivided into four sections, two of which

are ponton and two abutment sections. The former contain 3 ponton wagons and 1 chess wagon, and the latter 1 chess and 1 trestle wagon each. Each section contains material for three bays, and is never subdivided.

The supply division is provided with articles to replace those worn out or lost, such as chess, balk, spare parts of carriage, &c.

The carriages of each division consist of ponton, trestle, chess, and tool wagons, and of forges.

The ponton and trestle wagons are alike, and have inclined wagon-beds, the front end being sufficiently high to permit the front wheels to pass under it in turning, thus allowing the carriages to turn in a very short space.

The weight of each ponton and trestle carriage is 2,200 pounds, and loaded the former weighs 5,100 pounds and the latter 4,835 pounds. The chess carriage differs only from the ponton wagon in being of lighter construction and in having shorter side-rails. This wagon weighs 1,750 pounds without its load and 4,130 pounds with it.

The tool wagon differs from that furnished by the Quartermaster's Department, United States Army, only in the form of its body. The weight of the wagon without load is 1,800 pounds, and loaded 3,800 pounds.

The forge is the same as that issued by the Ordnance Department, United States Army, which weighs without load 2,217 pounds and with it 3,383 pounds.

Each ponton, trestle, and chess carriage is drawn by eight mules or six horses, and each tool wagon and forge by six mules or four horses.

The trestle is the same in form as the Birago trestle. The trestle cap, however, is a built beam instead of a solid one, as in the latter.

The pontons are modeled after the French wooden flat-bottomed batteaux. They are each of about 9½ tons burden, and have sufficient capacity to transport 40 men fully armed and equipped besides its crew of pontoniers. Its weight is 1,600 pounds. The balks are of two kinds, the long balk, 27 feet in length, and the trestle balk, 21.8 feet in length. Both of these are provided with cleats or claws, the former with one and the latter with two at each end. In the ordinary bridge the corresponding long balk of the adjacent bays lap each other about 6 feet and are firmly lashed together, and both to the gunwales of each boat, the cleats catching against the exterior of the boat. The length of each bay is 20 feet. The claws of the trestle balk catch on both sides of the trestle cap, and are so located that a trestle span is also 20 feet in length.

The chess is 13 feet in length by 12 inches by 1½ inches. To secure it from splitting, a rivet three-sixteenths of an inch in diameter is passed through each end.

Advance-guard equipage.

These trains are composed of four ponton divisions, each of which consists of eight pontons, two chess and two trestle wagons.

The ponton wagons of this train are the same as the chess wagons of the reserved train and weigh, loaded, 3,735 pounds. The chess wagons weigh, loaded, 3,606 pounds, and the trestle wagons 3,810 pounds.

The total wagon and forge are the same as in the reserve train, though the load of the former is reduced about 250 pounds. This weighs, loaded, 3,638 pounds, and the forge, loaded, the same as before. Each of these carriages is drawn by six mules or four horses.

When a forced march is to be made, the loads of these wagons may be considerably reduced by removing the chess which forms a part of the load of the ponton wagon, the rope from the trestle wagons, and reducing the number of chess carried by the chess wagons. In this case the number of the latter must be increased.

The ponton is modeled after the Russian canvas ponton and weighs 500 pounds.

The trestles and trestle balks are the same as in the reserve train. The short balks are 22 feet by 4½ inches by 4½ inches, with 20 feet 10 inches space between the cleats.

A more detailed description of these trains may be found in "The United States Bridge Equipage and Drill," published by the Corps of Engineers, United States Army.

APPENDIX.

REPORT OF COL. H. W. BENHAM, U. S. CORPS OF ENGINEERS, BVT. MAJ. GEN., U. S. A., UPON LAYING OF PONTON BRIDGES, PONTON TRAINS FOR LIGHT TROOPS, PICKET SHOVEL.

UNITED STATES ENGINEER OFFICE,
Boston, Mass., September 16, 1876.

DEAR SIR: I have to acknowledge your letter of the 9th instant, in which you invite me to mention for examination any "engineering works or appliances" that I may think worthy of consideration in the exhibit of our corps at the present exposition.

Though there perhaps are not many such appliances, whatever the designer may think, of use, that would meet the sanction, as of general value, of other or outside boards or committees, yet, as there have been some devices that occurred to me during our recent civil war that appeared of value, especially as they have been noticed and have been thought worthy of attention in other distant nations, I will inclose you herewith a brief description of some of them, in case they should be thought of utility sufficient to receive the notice of the committee who may act on such matters.

The matters to which the inclosed sheets (of some 7 pages only) refer are: A project that occurred to me (in my command of divisions and of the Engineer Brigade) for a more rapid construction of ponton bridges than I had ever heard of, or even to this time have ever learned, after frequent inquiry, has ever been proposed by any other person, or practiced in any other army.

It is a system, in following the nomenclature used, of "by successive pontons," that I have styled as "by simultaneous bays." It is, in fact, a plan for constructing the bridge completely on the shore at which *it arrives*, and then swinging it into position for the passage of troops. This can be done (as I have fully demonstrated and used it) in all ordinary positions, to the building of a bridge of 1,000 to 2,000 feet or more in length, in a matter of some 20 to 25 minutes. A bridge of 1,000 feet long I have repeatedly had built and swung into position for the passage of troops in some 18 to 20 minutes.

I am well aware that long before our time armies in retreat had cut adrift, had swung from one end, or destroyed in any way they could do, the ponton bridges upon which they had passed over water-courses. But I cannot learn of the record or suggestion even, of the regular or even the isolated construction of such bridges for the advance of an

army, in the way I propose, or in any other similar manner. Even the preparation of "rafts" as previously used "by conversion," as I understand, was done by "successive pontons," and never by having a construction squad at each bay to complete the whole, as this plan insures it, in about the same time that one bay only is finished by the plan of "successive pontons."

Such as this proposal is, it appears, with the devices afterwards mentioned, as well as others above alluded to, to have received the approval of our old professor of engineering—Mahan—with his intention to introduce them in his course of instruction and a copy of whose note in reply to my letter, sending him a description of these projects I herewith inclose you. I also add to this a report of light but efficient ponton train that I got up for the Army of the Potomac, in the winter of 1863–'64, which you will see by the description and the reports of the weights (which were accurately taken, as I have the details) involves a load of only 1¾ tons including trucks for each 20 feet of roadway.

I also send a description of a light "picket-shovel" of only 28 ounces weight that it occurred to me to devise, and propose in July, 1864, and which began to be called for in large numbers—by tens of thousands—as the last campaign of the war opened, early in 1865. This has been especially noted in foreign publications, and I may add that it was mentioned by General Meade as "universally approved," in an official letter recommending my brevet as major-general; and General Hancock, in acknowledging a sample of one hundred sent him on September 13, 1864, says, "I have examined them, and without trial, I can say they are just what is wanted, and they could not be improved." Professor Trowbridge, our engineer agent in New York, and formerly of our corps, who aided me to get them made, pronounced them the "grandest invention of the war;" and Colonel Wiley, of the staff at City Point, expressed the belief, if our troops had had them at the Spottsylvania campaign, that they "would have saved twenty thousand men," saying that, besides their proposed ordinary uses, he had frequently seem them indented by musket balls, from use as shields for the head in advancing to battle.

I inclose a letter (slightly changed) such as I sent to Colonel Ruggles, Assistant Adjutant General, Army of Potomac, reporting upon this improvement, and recommending its being provided for all infantry troops in the field. And to this I have appended a detailed description that perhaps may suffice without any drawing, though a sketch-drawing is also sent with this.

I noticed recently that even the "trowel bayonet" had been proposed for our cavalry in the Indian country for the purposes for which this shovel is designed; while from this it is obvious no injury or bending of gun barrels can be feared, as in the case in the use of the other implement.

There were some other devices that occurred to me and were put in practice in the field-works I had constructed in Virginia, such as the modifications of the outlines of ditches for greater security as defenses, and for more permanence to their slopes; also in the arrangement of obstructions in front, in lieu of the old regular "troupe de coup;" such excavations were made irregularly, with the soft removed earth placed in *piles* between the holes, which formed an absolutely impassable defense, superior to any abatis or slashing. Yet such changes or modifications do not appear of importance enough for description, or for more than a passing allusion in such a case as this.

Very respectfully, yours,

H. W. BENHAM,
Col. Eng'rs, Bvt. Maj. Gen'l.

Capt. D. P. HEAP,
U. S. Engineers.

WEST POINT, *April* 21, 1869.

MY DEAR GENERAL: Your letter April 12 reached here during my absence on a trip to Washington. I need hardly say that I am very thankful for the trouble you have taken in sending me copies of your papers concerning matters of so much professional value, to which I shall direct attention in the course of my instruction here. It would be well, I think, for you to send copies of them to General Abbot, as of special interest to the school of practice at Willet's Point.

Yours, very truly,

D. H. MAHAN.

Maj. Gen. H. W. BENHAM, U. S. A., *Boston.*

DESCRIPTION OF THE LAYING OF PONTON BRIDGES BY THE METHOD OF SIMULTANEOUS BAYS.

As the plan of laying bridges by "successive pontons" appeared to require too great an amount of time, and so few men could be employed, even while a whole army might be idle or waiting, it occurred to me while inspecting the drill of the first ponton train attached to my command during the late war, at Beaufort, S. C., in April, 1862, that a much larger number of men might be employed, and with greater safety, by building the bridge along the hither shore, and with a bridge squad working simultaneously between each two pontons, the bridge, when constructed to a sufficient length, to be then rowed around to the desired position, and the ends attached to the shore.

For this practice I directed the pontons to be placed along the shore at their proper distances, 20 feet, with a load of "chess" and "balks" between each pair of boats, as if left from a train which had closed to such distance, and had its teams wheeled separately, when they could all (on the usual river banks) be unloaded simultaneously, or in the same five minutes ordinarily; and then, with bridge squads of five to seven men, they were to proceed to lay the bays between each two boats. I at first directed that the two outer balks should be placed in succession from one end to the other (of the length of bridge estimated as necessary to span

the stream), but the movement of any part, or of the whole, proved so facile in the water that even the slight delay for this was found not to be necessary, and each or any pair or number of boats were brought together without hindrance or inconvenience from the incompleteness of the adjacent bays.

In the construction of these bridges—the material having been placed along the shore as above stated—the force available was divided into "bay squads" of about six men each, under an artificer or non-commissioned officer, and with a few simple and regular words of command the construction was commenced between each two boats at the same time. The squads (except the oarsmen in place, take their position upon each bay as completed and united, or partially united, to the adjacent bays.

This union of all the bays is usually accomplished in from five to seven minutes only, and at nearly the same minute, with men at all skilled, at which time the whole bridge raft, of whatever length tried, was ready for moving, the men belonging to them being seated in the anchor boats, keeping them on a slight strain to guide the bridge out and during the constructing of the bridge raft one larger squad was engaged in preparing the hither approach or shore bay, while a second similar squad would start with the materials to construct the opposite approach, which was usually done by the time the bridge raft could be swung to join it, the last squad, of course, not being used, in case of an opposing force.

When the raft was ready, the squad standing or sitting upon each bay, or if resistance or a fire was apprehended, the men with their arms if needed for the attack, are directed to lie down under the roadway in the pontons; and a good additional relief man to be near each of the oarsmen, who are the only persons exposed above the gunwale, except an officer or non-commissioned officer sitting near the oarsman of, say, every third boat. When the men are thus arranged, at the word given, the oarsmen all pull out strongly, especially from the center to the outer ends, as also in the anchor boats, to keep clear of the raft and to guide it, and the hither or pivot end moves also in a small circle held by ropes; and these rafts were brought into position (the outer ends moving with great rapidity) at the Eastern Branch* in from seven to eight minutes, generally, according to the current. During the movements all persons not needed for actual service were directed to conceal themselves below the gunwale, and preferably, for great danger, under the bridgeway itself, where it was found that twenty armed men could be comfortably placed in each boat, which would thus give an active force of one man for every foot of bridge (or thirteen hundred men for the bridges there tried) that could rise from their covered positions at the moment the farther shore was struck, to land at once, as a storming column, to sweep away any ordinary opposing force.

This bridge raft, it is obvious, does not need that the farther approach

* Of the Potomac River at Washington.

should be laid (as it could not be, if opposed) for the debouch of a storming column from it, for, by assuring that it shall be of full length, it must touch the opposite shore, so that men could readily land from it. And more than this, it has the advantage of being easily transferable to the other near positions if special opposition appears to be preparing at the point selected, the set of the boats being right for ready passage up or down a stream, and this quite easy with men at all trained at the oars. I found by trials on the Appomattox in 1864, that a long bridge raft was as easily wheeled or moved in any direction where it could float as a battalion of troops. I found, also, after strengthening the end to go forward by thick plank shields, covering the whole exposed side of each of the first three or four boats, and putting extra binding balks well lashed on the chess, that with a good steamer, a long bridge raft could be towed several miles an hour against a pretty strong current, the axis of the bridge being on the line of the stream. This at times might be quite useful, as is evident, where a bridge was desired above the point occupied, but where it would be more dangerous to land the materials and construct it even as above.

The further advantage of this system will be evident on a comparison with the old plan of "successive pontons," where, whatever space there might be, and how favorable soever the banks, nearly the whole of the troops had to remain idle, and perhaps exposed, while but one or two small bridge squads, of fifty or sixty men each at the most, could act. Every truck and wagon has to come up and unload at the bridge end *in succession;* while the men have to carry on their shoulders the whole bridge roading and fixtures, in all cases the average distance of *half* the length of the bridge, or 600 feet for a 1200-foot bridge. And in long bridges, where double sets of men are used, they interfere most seriously with each other, notwithstanding all precautions. The consequence is that many hours, not to say whole days even, are required for laying bridges of even a few hundred feet in length; besides, there being no cover for the men as they approach the farther shore.

This impracticability was fully demonstrated at Fredericksburg, where it could not be accomplished at all, in the face of even a moderate opposing fire, nor until that fire was previously silenced by other means; and to take up this bridge and reload it by this old system almost an equal amount of time is required; while by this new method of "simultaneous bays," as stated, many times the number of men can be employed to expedite the work, while the army is waiting—on ordinary banks, say eight hundred to one thousand men for a bridge of as many feet, although one-half the number may, if necessary, suffice for a rapid construction. The pontons are run off the trucks, and the chess and balks between each pair of boats are unloaded and placed ready for laying in the same five or ten minutes, the bridge raft completed in as many more minutes, and the bridge is swung ready for use in the same additional time as stated. While in swinging the bridge to its position

for use none of the men, even of the storming party, are exposed to the aim of the musket, except the directing officer or non-commissioned officer at every third boat and the two oarsmen to each ponton; and these, especially the latter, with the oscillating motion of the body in rowing, together with the motion of translation in the large circle they are passing so rapidly over, would prove to be targets almost impossible for the best marksmen to hit; and the men would need to carry the roadway material but a few feet only to the pontons at the shore edge; and the squads can interfere but little, if any, in all their work. And in dismantling the bridge the same facilities for separating and reloading the different parts will be available. And as to the places suitable for constructing on this plan, I cannot doubt that, with good judgment, it can be used in nearly all ordinary positions. It would require, however, in the case of rugged or high banks, a large force to assist, which must be readily available, from the fighting corps that are awaiting the bridge. Just previous to the battle of Chancellorsville, in the preparation for crossing below "Banks' Ford," at our position, where the river banks were some 80 or 90 feet high, steep and closely wooded, we had several "chute" ways cut, down which we intended to slide the pontons to the water, which, with a strong force to manage and hold them, we felt sure would be feasible, though there are few places more unfavorable for construction of a bridge upon this plan.

I may add that, as simple and obvious to any one as this construction of a ponton bridge by "simultaneous bays" appears, I have never been able to learn that it has ever been tried, or suggested even, before I had made those experiments so successfully, as above described.

PONTON TRAIN FOR LIGHT TROOPS.

Another useful device, was a modification of our light or canvas ponton trains, which was made by the Engineer Brigade, under my orders, during the reorganization of the ponton trains at Washington in the winter of 1863 and 1864. This was, to reduce the width of roadway 2 feet, the weight of the truck down to near 1,200 pounds, so that, with the canvas ponton of 22 feet long, and 650 to 675 pounds, the whole weight of everything (including this wagon or truck) for 20 feet of bridge, that is, boat, balks, chess, anchor, cordage, and truck, was *only* 3,500 pounds. For this, balks 4 by 4 inches were found to be sufficient, and that it would suffice to let them cross the boats alternately, (and not, as was usual to have each stringer or balk, cross *both* adjacent boats), and the balks were reduced to 23 feet in length, the chess or plank were reduced to 11 feet in length, which gave a roadway of over 8 feet. The canvas of the boat was *rolled* to prevent crackily folding, and put in a long box equal to its width, which box held also the small cordage and tools and the wooden cross pieces of the boat frames. The balks were loaded first on the light, strong truck; next, the side frames; next, the chess in two sets, one over the fore and the other over the hind wheels,

and the long box above, with the cable, and the anchor being beneath the balks, as usual. These light trains could be moved rapidly with six horses, or even with four horses on tolerable roads, and were found most effective for rapid marches, as they would readily bear up cavalry, and even light artillery. I may add that the reducing of the chess 2 feet in length, for a narrow roadway, was called for from officers with the moving column, most of the other arrangements for this light train were directed by myself.

H. W. BENHAM,
Brevet Major-General.

HEADQUARTERS ENGINEER BRIGADE,
AND DEFENSE OF CITY POINT, VA.,
March 23, 1865.

Col. GEORGE D. RUGGLES,
Assistant Adjutant-General, Army of the Potomac:

COLONEL: As I have been called upon by different officers, including, with others, Colonel Duane, acting chief engineer Army of the Potomac, for my opinion as to what troops (and in what proportion) should be furnished with the new army *picket shovel*, I would therefore wish to give you, with that information, a description of this implement, with its uses, that the expediency of such suggestions as I make may be better understood.

I take it that the events of war, and especially of the last campaign of this army, have developed the fact that in a large majority of cases, where armies are opposed, spades, properly played, to use the expressive phrase, "are trumps;" and especially in a country where they can readily be made use of in the soil, as is the case in all of our Southern States, except, perhaps, some small portions of mountain tracks, where the war has not been vigorously pushed.

This being the fact, I can scarcely conceive a case where a moving army or column, properly guarded by scouts or skirmishers in the front, cannot have assured to it always from a half to two or three hours' notice of the approach of a superior enemy, and therefore, for that length of time at least, the opportunity to bury or intrench itself in the earth to meet and resist such a force, if every man, or every second man even, should be provided with one of those picket shovels as a habitual part of his equipment.

The result of such protection against attack, I would say, needs no discussion with any one who doubts that the strength of the party using the spades will be at least doubled. In fact, each man carries his defense and protection upon his person, for there really is combined in the implement of 28 ounces' weight nearly all that was relied upon in the ancient shield, or the mailed armor of later ages, with whatever is gained by the modern field works.

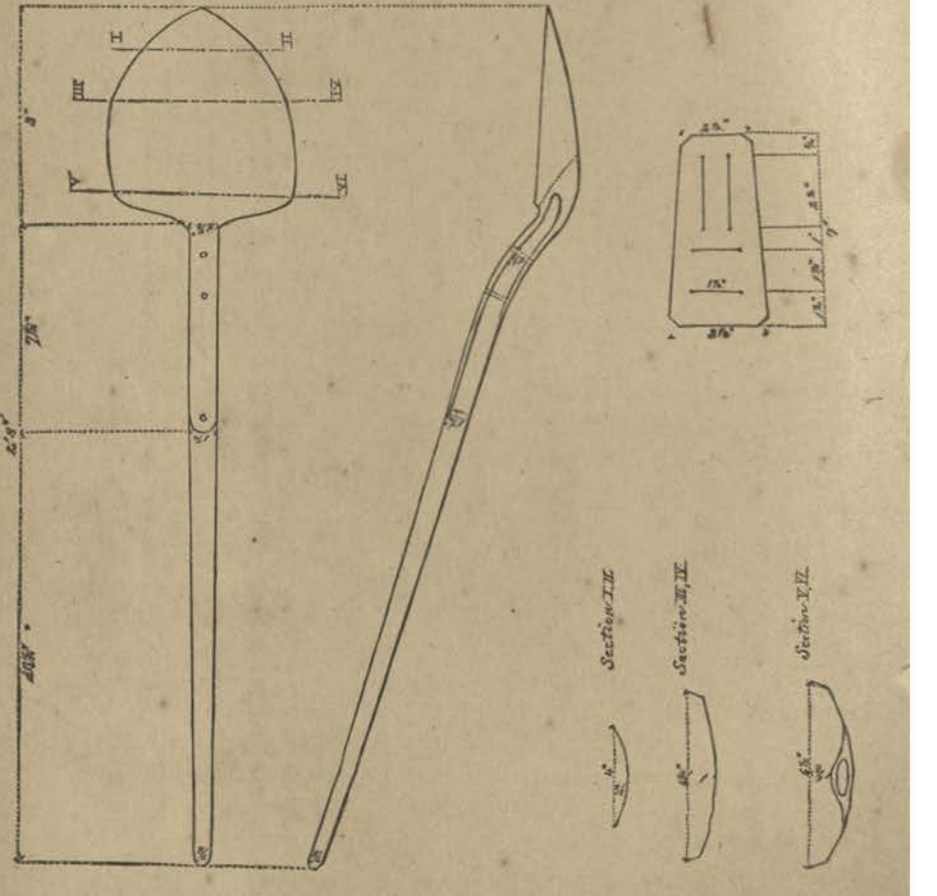
If I am correct in this, may we not look upon this picket shovel as a *new implement of warfare* for the equipment of all infantry troops for

field service, if, indeed, it would not be found to be often very useful for artillery service, and, indeed, for cavalry, even, in cases where they may be surprised and obliged to dismount and defend themselves. And with such uses or necessities, I can have no hesitation in recommending that this implement be provided for all the armies of the United States, and that it be issued to the troops in the field, and as regularly as the musket, and in such proportion that at least every second man shall be supplied with it. For, by working rapidly, by alternate reliefs in case of surprise, such number may suffice for all the troops.

The cost of these shovels, of the best quality of steel with welded straps, being but about $1 each, I may add that even if renewed every three or four months, they would not add to the expense of troops more than the amount of one cent a day.

Very respectfully, your obedient servant,

H. W. BENHAM,
Brigadier-General.



Description of picket-shovel.

(Weight, 28 ounces.)

This shovel is essentially of the post-hole scoop shape. It has a tapered, reverse curve handle of white-ash or hickory, 2 feet long, and a hollowed and pointed blade of steel plate $\frac{1}{8}$ inch thick. Blade, $8\frac{1}{2}$ inches long by $6\frac{1}{2}$ broad *when bent;* two steel straps, welded (or riveted) to the blade, unite the blade and handle by three rivets; upper strap, 11 inches long; lower strap, 6 inches; sides of blade *may* be turned for stiffness at nearly a right angle; but this bent edge narrows in width from $\frac{5}{8}$ to $\frac{1}{8}$ inch at $5\frac{1}{2}$ inches from the head, from which the edge of the blade is curved in a sort of *Gothic arch outline* to a point, $8\frac{1}{2}$ inches from the handle.

A plain staff handle, $\frac{7}{8}$ inch diameter at end, $1\frac{1}{4}$ inches at upper rivet, and flattened to 1 inch or less at entrance to blade, between the straps. It is readily carried in a "frog" at the waist, the blade above resting in the hollow of the back or side.

THE ORDNANCE DEPARTMENT.

FIRST LIEUTENANT HENRY METCALFE,
ORDNANCE DEPARTMENT,
IN CHARGE OF ORDNANCE SECTION OF THE WAR DEPARTMENT PARTICIPATION IN THE EXHIBITION.

LIST OF CHIEFS OF THE ORDNANCE DEPARTMENT SINCE ITS ESTABLISHMENT IN 1812.

Decius Wadsworth, Commissary-General of Ordnance from July 2, 1812; Colonel of Ordnance, May, 1815, to June, 1821.

George Bomford, Lieutenant-Colonel of Ordnance in charge from May, 1821; Colonel of Ordnance, May 30, 1832, to March 25, 1848.

George Talcott, Colonel of Ordnance, March 25, 1848, to July 10, 1851.

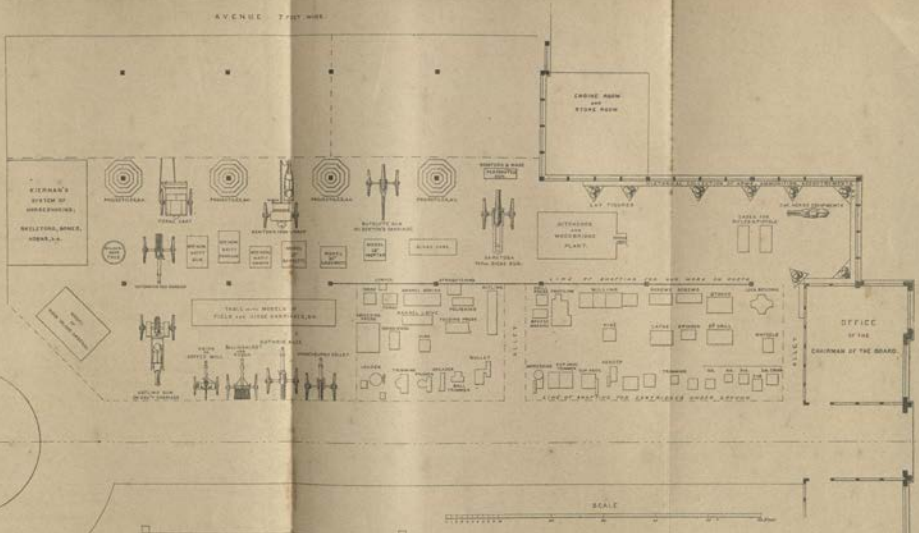
Henry K. Craig, Colonel of Ordnance, July 10, 1851, to August 3, 1861.

James W. Ripley, brigadier-general and Chief of Ordnance, August 3, 1861, to September 15, 1863.

George D. Ramsay, brigadier-general and Chief of Ordnance, September 15, 1863, to September 12, 1864.

Alexander B. Dyer, brigadier-general and Chief of Ordnance, September 12, 1864, to May 20, 1874.

S. V. Benét, major of ordnance, Acting Chief of Ordnance, February 4, 1874, to June 23, 1874; brigadier-general and Chief of Ordnance, June 23, 1874.



INTERNATIONAL EXHIBITION, 1876.

Board on behalf of U. S. Ordnance Department.

ORDNANCE SECTION, WAR DEPARTMENT EXHIBIT.

R. G. LYFORD,
1st Lieut. Colonel, U. S. A.
Representative of War Department.

REPORT OF LIEUT. HENRY METCALFE, ORDNANCE CORPS, IN CHARGE OF THE ORDNANCE EXHIBIT OF THE WAR DEPARTMENT PARTICIPATION AT THE INTERNATIONAL EXHIBITION, 1876, TO THE CHIEF OF ORDNANCE, WAR DEPARTMENT.

INTERNATIONAL EXHIBITION, 1876,
Philadelphia, Pa., July 25, 1876.

SIR: In accordance with your directions, I have the honor to make the following report of my operations in charge of the Ordnance Section, War Department Exhibit, during the past year:

I have substantially carried out the plan originally proposed by me for the representation of the Ordnance Department. This has included the mounting of the following heavy cannon, with their implements:

20-inch Rodman-gun; 13-inch sea-coast mortar, with center-pintle chassis; 9-inch Sutcliffe breech-loading rifle; 8.4-inch Mann breech-loading rifle; 8-inch converted muzzle-loading rifle, with model of case-mate.

The 12-inch Thompson breech-loading rifle is exhibited slung in the Laidley gun-lift, and the 10-inch Woodbridge muzzle-loading rifle suspended in the Laidley hydraulic sling-wagon, both of these guns being so exhibited in order to utilize space, and at the same time to illustrate the functions of the two machines named.

This arrangement gives a fair idea of our heavy ordnance, characteristic specimens of all kinds now in use having been selected. The same idea is pursued in the representation of the carriages, the hydraulic buffer being represented with the 20-inch gun, the pneumatic buffer with the 8-inch rifle, and Sinclair's friction-brake being shown on the carriage for the Sutcliffe 9-inch rifle. The 20-inch gun is provided with a windlass of my devising for drawing it from battery with six men. These guns are all mounted on platforms of solid yellow pine, similar to that shown in the report on the 8-inch rifle. These platforms are supported on 4-foot piles, resting on transverse mud-sills, these precautions being necessary on account of the unstable nature of the ground, which is principally loose filling. Near each gun are shown specimens, fired and unfired, of the principal projectiles used in it, and within the building are sample cartridge-bags for each gun, filled with an excellent imitation of hexagonal powder, kindly made at my request by the Messrs. DuPont.

Within the building, arranged in proper groups, are shown specimens of all spherical projectiles, of the principal rifle-projectiles used during the war on both sides, many curious shot depending on air and gas rotation, and a separate collection of the principal rifle-projectiles of the present day. In proximity to them are shown the cartridges belonging to them.

Siege-guns are represented by the 4½-inch muzzle-loading rifle and 8-inch howitzer with implements, both mounted, the former on Colonel Benton's iron carriage; and two 24-pound Coehorn mortars mounted.

For field-guns, I have the light 12-pounder mounted on the wooden carriage, the 10-pounder Parrott on General Hagner's iron carriage, and the 3-inch rifle on Colonel Benton's iron carriage. To the limber of this is harnessed a model of a horse and artillery-driver, with a complete outfit of accouterments, equipments, and arms.

All breech-loading field-pieces are exhibited within the building mounted upon walnut skids, upon a massive table specially prepared for them. On one side of it are shown the Sutcliffe, caliber 3.15 inches; the Moffat, 3.07 inches caliber; the Mann, caliber 3 inches; and the Hotchkiss, caliber 3.15 inches. These are so placed as to be easily worked by hand. Opposite them are the Hotchkiss breech-loading mountain-rifle, caliber 1.63 inches; the experimental trial Woodbridge gun, caliber 2.5 inches, and four curious breech-loading rifled boat-howitzers of presumably rebel origin.

Along the middle line of the table, fronting each other, are a Whitworth rifle, and an old Spanish breech-loading piece about 1.5 inches caliber, dated 1570, presented by Messrs. Morris, Wheeler & Co. It came from New Orleans, where it was probably dredged up from the bottom of the Mississippi. It bears every appearance of having been under water for many years, and is probably a relic of the Spanish occupation of Mexico. There are also of historic interest a siege-gun and Gribeauval carriage, (Revolutionary), used at the battle of Saratoga; four guns known as part of an old Spanish battery, called after the Twelve Apostles, a relic of the Spanish occupation of Louisiana, and probably ceded with that b the French; six 6-pounders and two 10-inch mortars, French, very ornate, supposed to have been presented to the Government by La Fayette. These, with the help of a festooning of bronzed chain, form an inclosure containing models of the Rodman, Hitchcock, and Woodbridge gun-plants, all on the scale of $\frac{1}{12}$, the Hitchcock model working as in actual practice, air being used instead of steam. All the tools, hooks, cranes, trucks, &c., of the latter process are faithfully represented. Near these models are shown specimens of the materials from which the guns are actually made; the wire for the Woodbridge gun being shown in coils, with the winding-apparatus, and an immense Dank's sponge, in several stages of manufacture, standing near by. Specimens of the latter iron, twisted in every way, and rolled to the astounding tenuity of $\frac{1}{1832}$ inch, testify to its good quality when properly treated.

There are also tested specimens of various kinds of cannon material, with labels indicating the strains to which they have been subjected. There are also several bronze howitzers cast by Byers, in Philadelphia, 1777, one bearing the name "Mercer," presumably that of the then Master-General of the Ordnance, with his coat of arms. Another, probably cast later, bearing instead the more democratic device, "The people."

Also, several 3-pounder howitzers, cast by D. King, Germantown, probably at about the same time, and associated with the name of "Mad" Anthony Wayne.

The following machine or mitrailleuse guns are shown. They form a historical series, beginning constructively with the Vandenburgh volley-gun; then the Requa battery; the Guthrie and Lee repeating two-barrel gun, and the Union repeating or coffee-mill gun. Then is shown the Gatling gun, short barrel, caliber .45, mounted on the new cavalry-carriage, to which is harnessed the stuffed horse "George M. Patchen," and a horse-shaped trestle, with the driver's saddle, detachable single-tree, &c., complete. A cavalry forge-cart, similarly attached, is also represented. There is also the Hotchkiss revolving cannon, 1.63 inches caliber, and the smaller mitrailleuse on the same plan. Two mountain-howitzers, one packed and the other on the prairie-carriage, complete this show of cannon, with exception of a large collection of models of field, siege, and sea-coast cannon and carriages.

Under the head of cannon-ammunition, beside the display already spoken of, I expose gunpowder in very many forms, especially including General Rodman's early inventions of perforated cake-powder, both hexagonal and in large short cylinders pasted together to form the cartridge. Specimens of gunpowder of various sizes and of different nationalities are also shown; also a collection of 74 fuses, primers—friction and electric—and various means formerly employed in firing cannon.

The small-arm collection is especially full; it contains 53 specimens of muzzle-loading military guns, 154 of breech-loaders, all of them different in principle or in purpose, 47 pistols and revolvers, and a miscellaneous collection of swords, sabers, and knives. Almost all prominent military systems, domestic or foreign, are here shown. The small arms are arranged according to the classification adopted by me in preparing Ordnance Memoranda XV. This classification has stood the test of the introduction of so many new systems remarkably well.

In small-arm ammunition I have profited largely by Capt. William Prince's excellent collection of bullets, powder-cartridges, and cartridge-cases, without which this exhibit would have been very incomplete. In connection with this are shown all principal varieties of cartridge-cases in progressive stages of manufacture, targets made with the service-rifle at different ranges, &c.

In leather-work are shown a historical series of accouterments mounted on lay-figures, from the supposititious minute-man armed with a flint-lock musket used at the battle of Bunker Hill to the infantry soldier of the present day with the new equipment and the addition of the cartridge-block and trowel-bayonet. Besides these two figures there are represented the rifleman of 1815–1820 with the Hall breech-loading rifle; the infantry soldier of the Mexican war with the percussion musket, model 1842; the cavalry soldier of the war of the rebellion with the Spencer repeating carbine and cartridge-box; the infantry soldier

of the same epoch armed with the Springfield muzzle-loading rifle-musket; the infantry soldier of the present day with the full set of new equipments armed with the Springfield rifle, caliber .45, and a cavalryman, mounted, with the entire outfit prescribed in Ordnance Memoranda No. 18, and armed with Springfield carbine, and Colt's revolver, caliber .45, and saber.

The most interesting feature of the section of which I have charge is the machinery. This consists of a full set of cartridge-machines, 19 in number, making 5,000 blank cartridges, caliber .45, per day, and 21 machines of a typical character at work upon component parts of the Springfield rifle, caliber .45. The former are run by operatives detailed from the Frankford Arsenal as a branch of that establishment, and the latter by armorers similarly detached from the National Armory. The former go to and from their work as usual; the latter live in tents in Camp Knox within the Exhibition grounds, and are fed at the United States mess-house near by. The product of all this work is turned in as a regular part of the daily fabrication of the two establishments referred to. This machinery is run by power obtained from two 10-horse-power Baxter engines with 15-horse-power boilers, run by two of the soldiers of my command.

I would especially call your attention to the arrangement of the belting and shafting, which is so arranged as to obviate the use of an extension scaffolding to support the counter-shafting. The main shaft is *above* the counter-shafting, which is fastened to the side framing of the building directly beneath it; from this the driving belts run obliquely to the machinery beneath. The gun-machinery, being belted from above, is placed next the main shafting; the cartridge machinery is placed on a more distant parallel line driven by an oblique belt from the main shaft, and is belted to an underground shaft below it. This gives me the overhead space entirely clear. Instead of the long, unsightly overhead shipper-rods usually employed, all of my gun machinery is provided with wire-cord connections with the counter-shafting. This runs over pulleys through grooves cut in the flooring, and by means of a wire spring on the counter-shaft shifts the belt with the greatest ease either on or off the loose pulley. These cords are so arranged that when the belt is on the driving-pulley the spring is compressed so that by simply loosening the cord the spring passes the belt to the loose pulley, instantly stopping the machine. In the arrangement of this machinery I have been greatly assisted by Mr. Jabez H. Gill and Mr. L. F. Bruce, my master-machinist. To Mr. Bruce I am indebted for the arrangement of the cord-shippers above described.

A series of boards contain every portion of the Springfield rifle in every stage of its manufacture, with the labels giving the name of the piece, that of the operation, that of the machine on which it is performed, and the number made per hour. Arms-chests packed with rifles and pistols complete the representation of the transition of the musket

from its raw material to its condition of immediate issue. A box of standard cleaning-materials is shown.

Near by the main Government building is erected a Laidley iron-frame laboratory, which is the same one blown up in August last at the Frankford Arsenal. This is erected so as to show its panel construction, section of the panels being cut out to illustrate still further its design. Within this building is placed a collection of the electro-ballistic machines used in the United States service and the mercurial densimeter. These are operated by competent attendants, firing for this purpose reduced charges from the Springfield rifles. Incidentally is shown herewith the fixed rest (Ordnance Memoranda VIII) and the recoil dynamometer. The firing is done through a wrought-iron tube for safety. In order to obtain commensurable readings and to prevent any disagreeable shock to visitors, low charges of 12 grains are used. The range is 35 feet; the ordinary velocity about 450 feet.

A rifle prepared for the Rodman gauge illustrates the theory of gas-pressures, which is still further manifested by the exhibition of pressure-gauges of different kinds for cannon. The original apparatus for a similar purpose by Majors Bomford and Wade, 1842, and the Woodbridge oil-pressure gauge are shown in the section devoted to field-pieces, with the gun on which they were tried. This department is under the especial charge of First Lieut. C. W. Whipple, United States Ordnance, to whom I am indebted for its efficient maintenance. In it is a working-model of the target-recording apparatus (Ordnance Memoranda VII) large enough for use by an inquiring visitor. A collection of inspecting-instruments for cannon, with the new star-gauge for rifled guns, is here exhibited.

The most interesting object of the exhibit, artistically speaking, is undoubtedly the model of Rock Island Arsenal, on the scale of $\frac{1}{300}$, prepared under my direction, by Baron F. von Egloffstein, New York, by means of the "photo-plastic" process, known also as "photo-relief" and "photo-sculpture." This consists in exposing a *positive* photographic view of, say, the end of a building, over a thick film of sensitized gelatine, covering a glass plate; the soluble, opaque portions of the gelatine are then washed out. The film is then swelled by a peculiar process, so as to magnify its differences of level, until a suitable relief is obtained. A plaster cast of the film then gives a permanent mold, from which many repetitions can be made. A successive series of these plaster views, taken from the different sides of a house, are mitered together at their edges, and when roofed in form an *absolutely perfect* reproduction of the house itself, every stone and crevice being represented. In the representation of the commanding officers' quarters there may be easily seen, with the naked eye, a lattice-work around the piazza, the slats of which, in nature, cannot be much over 2 inches wide, thus giving lines about .006 inch in width. The model represents the middle part of the island between the main river and the branch known as Sylvan Water. Upon it are represented the shops, railroad, store-houses, officers' quarters, gar-

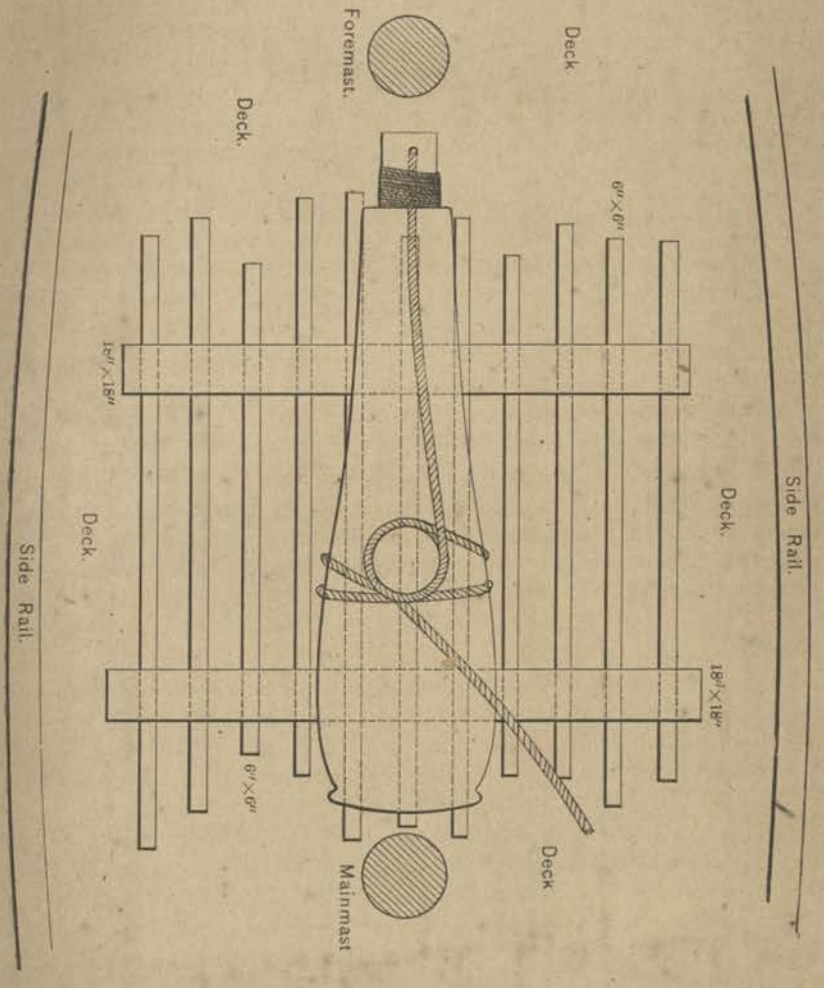
dens, barracks, hospital, reservoir, stables, and fountain; office, lake, river, roads, fences, paths, bridges, and many actual representations of typical Rock Island trees. These trees I believe to be something new in model-making. They are prepared as follows: A frame of twisted wire is first prepared from a photograph of the tree to be represented, giving the proper shape and size to the main trunk, limbs, and many of the small branches; this is then repeatedly dipped in a hot solution of gelatine, being alternately powdered with comminuted gelatine, to give the light appearance of leaves, &c. It is then dyed to the proper tone and set in position. The water is made of a double thickness of fluted glass, laid crosswise and covered with a layer of plain glass. This overlies a tinted topographical representation of the river-bed, and makes the most natural water effect I have ever seen.

To protect the model from dust, handling, &c., it is covered with a case, the sides of which are of glass, 3 feet high. For economy the top is of wood. As this darkens the model somewhat, I have provided a heliostat, moved by clock-work, which throws a stream of light upon a greater part of the model and produces a most picturesque effect by breaking up the ground-work with the shadows of trees, fences, and buildings. I believe this adaptation of the heliostat to be new and possibly of valuable application for the illumination of paintings ordinarily requiring a certain time of day to be seen at their best.

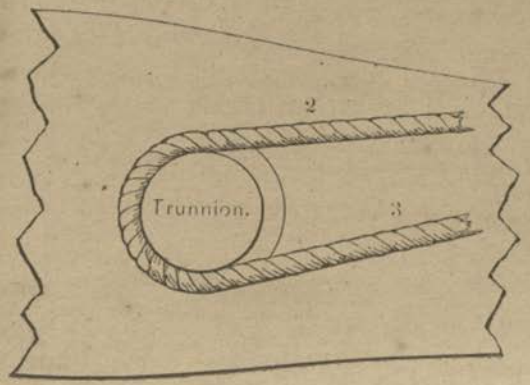
All attainable publications of the Department are freely exposed, and I am informed are frequently consulted by visitors.

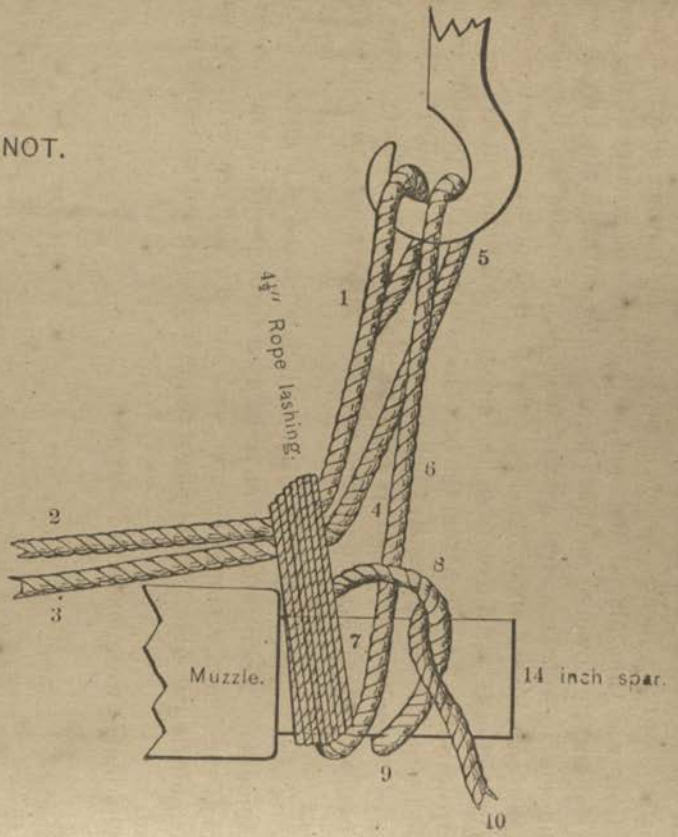
The decorations of the section comprise a large red and white banner, 10 feet by 12 feet, with the name of the Ordnance Department; two long pennants referring to the manufacture of cartridges and of the rifle, and a number of smaller pennants bearing the names of distinguished deceased officers of Ordnance. Above the line of small arms is a thick-set *frise* of bayonets pointing inward, and at intervals are massed piles of gun-implements, equipments, sabers, pennons, and lances.

In the preparation of this exhibition, with one exception, I have had nothing especially worthy of note in this report. This exception refers to the unloading and mounting of the 20-inch gun. This gun with a 13-inch sea-coast mortar of about 18,000 pounds, a cradle of, say, about 4,000, with heavy yellow-pine skidding and a deck-load of lumber, in all about 80 tons, was shipped to me from Fort Monroe on a vessel rated at 94 tons. She nearly foundered in a gale on Chesapeake Bay on her way to the canal at Baltimore, but arrived at this place afloat but leaking badly, with her deck only about 8 inches above the water-line and about 4 feet below the level of the wharf at high tide. The steam-crane on the wharf had been found by analysis to be insufficiently strong to lift the gun entire, it was consequently simply used as an auxiliary. A 14-inch spar was wedged tightly into the muzzle of the gun and served as a fastening point for the 11-inch hawser by which the gun was raised. The cuts here given show the position of the gun on the vessel and the arrangement of the lashing.


Foremast.
Deck.
Deck.
6"×6"
15"×15"
Deck.
Side Rail.
Side Rail.
Deck.
18"×18"
6"×6"
Mainmast
Deck

DETAILS OF HAWSER KNOT.





The gun having been blocked up about 2 feet from the cascabel, at 4 p. m. on Friday, November 5, the crane began to lift. It lifted the muzzle about 15 inches, beside stretching the hawser about 8 feet. Blocking was then placed just back of the center of gravity of the gun, and the muzzle lowered on this pile as a fulcrum until the breech was high enough to take a fresh pile of blocking beneath it. By this lift the gun was raised about 3 inches. The position of the three supports was as follows: 1st, 5 feet from the muzzle; 2d, immediately back of the trunnions; 3d, 2 feet from the breech. Owing to the position of the third point, the crane was strained about 13 tons by this lift. Double piles of blocking were used at each bearing point for safety, so as to limit any accidental fall in raising or lowering the gun to an inch or two at the utmost.

Chocking-quoins were also used to follow up the gun closely in its movements. About fifteen men were used throughout the maneuvers. One of these men, a ship-carpenter, with his adze and crosscut-saw, was particularly valuable. I had also a rigger from the United States navy-yard.

The hoists were made as follows:

No. of hoist.	Time.	Lift.	Remarks.
	P. M.	*Inches.*	
1	4.00	3	
2	4.30	3	
3	4.55	5	
4	5.15	5	15 tons on crane.
5	5.32	3	Took off the mortar with the crane and stopped work.
Saturday, November 6.			
	A. M.		
6	7.30	2.8	
7	8.00	2.25	
8	9.03	4.75	
9	9.31	3	
10	10.15	2.25	
11	10.40	1.5	
12	11.35	3.25	Crane withdrawn from use by proprietor from 12.30 to 2.30 p. m.
	P. M.		
13	2.30	2.25	It was observed that the muzzle had moved inward about 8 inches from the center line of the vessel, heeling the schooner considerably to port. This was corrected at 3 p. m. by a tackle fastened to side of the vessel, by which the muzzle was cut to a proper position. At 3.15 p. m., the breech having rolled slightly to port, it was rolled back an inch or two with pinch-bars.
14	3.45	8	
15	4.07	7	
Total ...	.....	57	20 tons on crane.

Heavy 18-inch yellow-pine skidding was then placed from under the gun to the wharf, inclining slightly upward, and the hawser parbuckled around the gun and fastened to the crane. A purchase was taken from the muzzle by a locomotive standing on a neighboring track. The crane began to hoist at 6.44, the gun immediately rolling toward the wharf

as the hawser uncoiled. The muzzle was cut meanwhile by the locomotive. At 7.04 p. m. the gun was landed, in eleven hours six minutes working time.

As the vessel was relieved of the weight of the gun it rose, converting the inclined way of skidding into a declivity leading to the wharf. This feature permitted the pile of blocking on deck to be much lower than would otherwise have been necessary. On Sunday the gun was rolled by the crane and locomotive together to a position parallel with the railroad track, across which it had been necessarily landed. Toward the latter part of this operation the locomotive was dispensed with, it being found that by placing the crane in a favorable position, taking hold of the muzzle and then topping the boom, the muzzle could be cut almost as well as with the locomotive. At 11.55 a. m. the first lift was made to raise the gun to a sufficient height for loading on the platform-car; nothing could be done, however, until 1.50 p. m., the filling of the dock of coal ashes, street sweepings, &c., being so soft that whenever the weight was concentrated on the breech it would keep sinking as fast as the muzzle was raised. Finally a wide platform was built under the breech, and the effective hoisting began at 1.50 p. m.; this was continued till 5 p. m., with the following result:

		Inches.	
1	1.50 p. m.	3.5	
2	2.00	4.0	
3	2.10	4.0	
4	2.20	4.0	
5	2.30	3.5	
6	2.50	4.5	
7	3.05	3.5	
8	3.25	3.6	
9	3.40	2.9	
10	4.00	2.5	
11	4.15	5.5	
12	4.20	4.5	Twenty tons on crane.
13	4.50	3.5	
15	5.00	4.5	
	2.30	54.0	

At 7.15 p. m. the gun was rolled to the car. At 8 o'clock it was on the car, on which it was transported safely the next morning to the Exhibition grounds, and unloaded the same day. The advantages of my position in this operation were as follows:

I. The proximity of William C. Allison & Son's wharf and their large car-works, from which I obtained readily supplies of blocking, flat iron bars, heavy tools, men, and notably the use of their steam-crane and railroad-plant. I found the 6-inch oak car-bolsters especially valuable for blocking.

II. The use of an extra heavy flat car procured from the Pennsylvania Railroad Company.

The disadvantages were:

I. The small size of the vessel, its breadth of 23 feet giving only 8 or 9 feet on each side of the bare gun to work in. The gun also occupied all the space between the masts. With the additional weight of the blocking upon her decks used in raising the gun, the danger of breaking them in or of starting fresh leaks was greatly increased.

II. The captain of the schooner refused to permit hydraulic jacks to be used for fear of breaking in his deck.

III. The gun had to be raised so high in order to roll it off upon the dock that the stability of the vessel was considerable endangered.

IV. The captain of the schooner refused to lie alongside the wharf, fearing shoal water; consequently the gun had to be rolled off from the end of the wharf at right angles to the railroad track.

V. I was obliged to do much of the work after dark in the hope of getting the gun on the car by Sunday, the Pennsylvania Railroad wishing to move it to the grounds on that day, for fear of obstruction to the track; otherwise I was liable to car demurrage.

VI. The men were unaccustomed to moving heavy weights and shirked all they could, especially at night.

I was much assisted in this work by Messrs. A. B. Bury, of this place, and R. W. Baylor, now in my employ.

I have ventured to give this full account of the work of unloading the gun in hope that the difficult and somewhat perilous circumstances under which it was performed, and the novelty of some of the processes employed, may be of interest or of possible value.

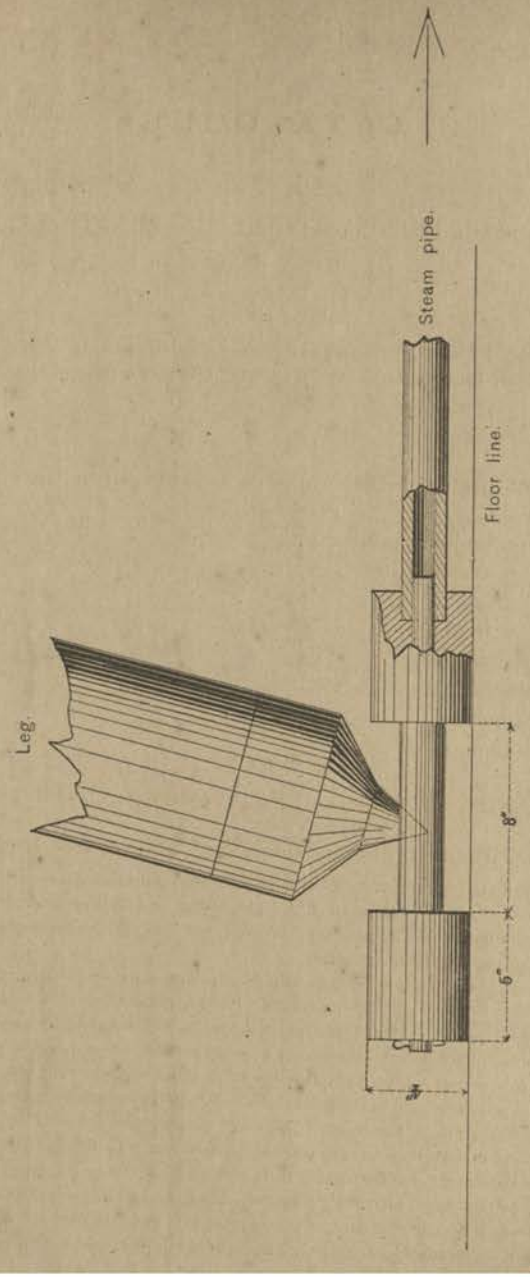
In mounting the 20-inch gun the Laidley gun-lift was used, assisted by blocking. The other guns were mounted with blocking only. The light auxiliary shears, provided with the Laidley gun-lift, proved of considerable value in placing in opposition heavy articles, such as the field-cannon, on the table spoken of, raising the ways of the drop-hammer, &c.

I also used a casemate-gin, mounted on three rollers. This was very useful in picking up heavy pieces, such as lumps of ore, drop-anvils, &c., and moving them to the pedestal or the foundation on which they were to be placed. Two of the rollers on the windlass-legs were joined together by a sleeve of heavy steam-pipe, fitting over the projecting limbs of the axles to prevent the rollers from assuming their natural position at right angles to the line of the leg.

Very respectfully, your obedient servant,

HENRY METCALFE,
Lieutenant of Ordnance.

The CHIEF OF ORDNANCE, U. S. A.,
Washington, D. C.



SKETCH OF GARRISON GIN ROLLER

CATALOGUE

OF THE

ORDNANCE COLLECTION AT THE INTERNATIONAL EXHIBITION, 1876.

First Lieutenant HENRY METCALFE, Ordnance Department, in charge, assisted by First Lieutenant C. W. WHIPPLE, Ordnance Department.

The subject-matter of the catalogue is arranged in the eight following classes:

A.—Cannon and carriages.
B.—Cannon ammunition.
C.—Small arms.
D.—Small arm ammunition.
E.—Equipments.
F.—Machinery.
G.—Instruments.
H.—Miscellaneous.

A.—CANNON, CARRIAGES, PLATFORMS, AND IMPLEMENTS.

No. 1. 20-inch Rodman gun, carriage, &c., made of cast iron.

Gun.—The gun was made at the Fort Pitt Foundry (Charles Knap, Pittsburgh, Pa., 1869). It was cast on the Rodman principle, being cooled from the interior. (*Vide*, Rodman's experiments, p. 307 *et ante*; Benton, pp. 136, 551; also model of plant for casting a 15-inch gun, inside building.)

Top carriage.—The principal feature of this carriage consists in the arrangement for running it "from battery and in battery." The front portions of the lower chords of the cheeks are cut away forward of a point opposite the bearing of the front maneuvering wheels, so that when the rear maneuvering wheels are thrown in gear by means of the eccentric axle on which they revolve, the front wheels support the weight of the gun, and it can move on rolling friction. When it becomes necessary to check the recoil of the carriage, the rear wheels are thrown out of gear by means of the handspikes, and the carriage moves on sliding friction. In front of the top carriage are two screw hydraulic jacks, used to lift this end of the carriage in mounting or dismounting the front maneuvering wheels. There is also a loading crane. The fulcrum part attached to the rear end of the carriage is used to elevate and depress the gun by means of a handspike inserted through the holes, and acting upon the rack in the breech of the gun.

Chassis.—The important feature is the hydraulic buffer. (*Vide* Report Chief of Ordnance, 1874, p. 130, Plate 7.) This is intended to still further check the recoil of the carriage by means of a perforated piston, fastened to the top carriage, moving in a cylinder fastened to the chassis through a mixture of glycerine and water or other liquid. The fluid resistance opposes a rapid movement of the piston, as in the case of recoil, but allows it to move freely, when slowly urged, as in the case of maneuvers. The holes in the piston flare at each end so as to facilitate the passage of the fluid. The carriage is drawn from battery *in drills and when the gun is not discharged by* means of a windlass at the rear end of the chassis rails. *This is worked with the hand*spikes belonging to the gun, the cannoneers bringing the gun back by a pumping motion of the handspike sockets. These contain following pawls, which catch upon circular racks keyed to the windlass shaft. Six men draw the gun back with ease. The gun is traversed by means of the geared traverse wheels into which mesh the pinion wheels at the ends of the traversing-crank shafts. This gives a continuous motion to the traversing and avoids the time lost in overcoming the inertia of the piece at each heave. Two screw hydraulic jacks at the front end of the chassis allow the gun to be raised so that the eccentric maneuvering wheels near at hand may be thrown in gear for traversing. These wheels are supposed to remain in gear except when firing at high elevation.

Implements.—Consist of 6 handspikes, 1 sponge, 2 rammers, 1 worm, 1 differential chain pulley, 4 shot hooks, 1 carrying bar. The implement holders (not the hooks) against the sides of the chassis are designed to support the implements when in use, and to shut up out of the way in transportation.

Platform.—The platform consists of five heavy sleepers radially disposed about the pintle, tied together above and below at their intersection by cross-courses of similar material. They are also secured at the bolster bearing and by the support for the traverse arc. As this platform is upon made ground, these sleepers rest upon four-foot posts resting again upon mud-sills. In good ground this precaution is unnecessary, mere water puddling with sea sand proving sufficient. This form of platform has endured remarkably well the shock of experimental firing at Sandy Hook and elsewhere.

Weight of gun, 115,100 pounds; caliber, 20 inches; length, 243 inches; maximum diameter, 64 inches; tensile strength, 30,078 pounds; density, 7.1999 pounds; weight of shot, 1,080 pounds; weight of powder (mammoth), 200 pounds; preponderance, 0 pounds; extreme range (25° elevation), 8,000 yards, 4½ miles.

No. 2. Model of Rodman method of casting heavy cannon. Scale 1 inch = 1 foot. (*Vide* Benton.)

The peculiarity of this system consists in the means which it affords for cooling the cast-iron gun from the inside of the bore. A stream of water runs through the small pipe, shown inside the core-barrel, and, striking the bottom of the core-barrel, rises and escapes from the lateral pipe at the top. After running thus for some time the core-barrel is withdrawn and the water allowed to come into immediate contact with the walls of the bore. To further prolong the cooling of the outside of the gun, a fire is built on the grate-bars at the bottom of the pit. The draft pipes lead downward outside the model. Above the model is shown the mixing pool and runners or gutters for rendering homogenous the product of the different melting furnaces required in casting a large gun; and the tripod by which the core-barrel is accurately centered in the mold. Down the sides of the mold are seen the gates through which the molten iron enters the mold. The core-barrel is cut open to show the water pipe. It is also unwound to show the flutings and wrapping of rope, through which the gases escape to the top, where they are consumed. The rope is covered with a coating of loam, which is porous to the gases, and yet prevents the rope from being burned away. The large 20-inch gun outside and the 12-inch rifle were cast in this way. (See General Rodman's report on cannon, and Benton, pp. 136, 552.)

No. 3. Light 12-pounder gun.

A bronze smooth-bore gun adopted in 1856 and modeled after the gun designed by Napoleon III to take the place of the variety of calibers used before in the French field service. It was used more extensively than any other field-gun during the last war, and was particularly effective where the character of the country required the fighting to be carried on at short ranges.

Cost of gun, $566; weight of gun, 1,229 pounds; weight of shot, 12 pounds; weight of charge, 2¼ pounds; velocity, 1,495 feet; diameter of bore, 4.62; extreme range, elevation, 10°, 2,090 yards (*Vide* Benton, p. 182); light 12 pounder carriage: weight, 1,175 pounds; cost of carriage and limber, $365; limber: weight, 860 pounds.

Contents of chest, packed: shot, fixed, 20; spherical case, 8; canister, 4; spare cartridges, 2; friction primers, 48; slow match, yards, 1.5; port fire, 2.

Implements: 2 sponges and rammer, 1 worm, 2 handspikes, 1 tar bucket, 1 water bucket, 1 prolonge. (*Vide* Benton, pp. 230, 234, and Ordnance Manual, p. 335.)

No. 4. 8-inch Siege howitzer.

Used for ricochet firing and for the purpose of battering the earth and fragments of masonry left standing in a besieged work after the fire of the breaching guns has ceased. It can be used as a mortar by reversing it in the trunnion beds of the carriage, with the wheels off and propping up the trail. (Benton, p. 186. Report Chief of Ordnance, 1874, appendix F, 12, 15.) Weight, 2,550 pounds; weight of shell, 46.6 pounds; weight of charge, 4 pounds; initial velocity, 1,060 feet; range, 12° elevation, 1,986 yards; fired as mortar, 1½ pound powder; 45° elevation, range 1,925 yards; 8-inch siege howitzer carriage (wood), weight, 2,522 pounds. (Benton, p. 239.) Implements—6 handspikes, 1 rammer, 1 sponge, 1 pass-box.

No. 5. Mountain howitzer. Cost, $160.

Weight of gun, 220 pounds; weight of shell, 12 pounds; weight of charge, ½ pound; diameter of bore, 4.62 inches; extreme range 5°, 1,000 yards. Intended to be transported on pack animals in mountainous country without roads. (*Vide* Benton, p. 183.) Carriage: weight, 289 pounds. Intended for transportation on pack animals when necessary. (Benton, p. 237.) Mountain howitzer packed, arranged on stands as for transportation, showing the method of lashing on pack saddles; howitzer and shafts; the remainder of carriage and implements, and the ammunition chests on separate animals. (*Vide* Benton, p. 183.)

No. 6. 13-inch sea-coast mortar; made of cast iron.

The center pintle chassis replaces the old wooden platform protected by iron plates formerly used with this mortar, saving much time in pointing. By means of the eccentric axle at the center of the chassis the weight is thrown on the traverse wheels while pointing. Before firing the chassis is thrown out of gear. Weight, 17,120 pounds; weight of shell, 200 pounds; weight of maximum charge, 20 pounds; extreme length 54 inches; length of bore, 2.7 caliber; range, 45° elevation; maximum charge, 4,200 yards; time of flight, 30½ seconds; weight of chassis, 2,000 pounds; cost of chassis $1,580; length of rails, 190 inches; height in front, 10 inches; height in rear, 15½ inches. (*Vide* Benton, p. 194.)

Implements 13-inch mortar: four truck handspikes (iron); two elevating bars (iron); blocks and fall (iron) attached to crane; sponge and staff; shell hooks, scraper, wiper, quadrant, pointing stakes and cord; maul, broom, plummet, carrying bar, in basket.

In mounting and dismounting this mortar it is slung by the bail attached to the trunnions by pins, in place of the sling rope, chain, or trunnion rings formerly used. The mortar can be elevated and depressed either by a single handspike working in the ratchets cut in the breech or by two handspikes fitted on to the arms attached to the trunnions.

No. 7. 24-pounder Coehorn mortar and bed.

Material, bronze; weight, 164 pounds; weight of shell, 24 pounds; weight of charge, ¼ pound; gomer chamber; extreme range, 1,200 yards; weight, 132 pounds. (*Vide* Benton, p. 188.) Transported by two men and used principally in the trenches during siege operations, on account of the effectiveness of its plunging fire against points protected by embankments.

No. 8. 12-inch Thompson breech-loading rifle, manufactured at the South Boston foundry.

Consists of a cast-iron body, embracing by light shrinkage a steel tube of uniform thickness, which is further secured in position by a screw at the breech end of the tube. The breech is opened by turning the weighted lever to the left. Two sets of teeth, one upon the rear washer of the breech spindle, and one upon the head of the breech block, engage with straight racks secured to the gun, and cause the whole fermeture to roll bodily to the left into a mortise cut in the side of the gun. A shot the size of the spindle is left in the body of the gun, to allow for the lateral motion of the spindle. The back of the head of the breech block has a spiral bearing against the body of the gun, so, when in place, a horizontal section of this part represents a wedge, with its thick end toward the *closed* part of the mortise. The gun is fired by means of a long firing pin driven by a spiral spring. This spring is compressed by drawing it back by hand, by means of a cross handle at the rear end of the firing pin. A simple catch, connected with the cross handle, engages with a nut surrounding the base of the firing pin, and keeps the spring under tension until released by a pull from the lanyard attached to an eye in the cross handle.

Weight of gun, 84,280 pounds; projectile, Butler's breech-loading projectile, with double bearings: Weight, 600 pounds.

Dimensions.

	Inches.
Exterior diameter of gun:	
At muzzle	27
At breech	47
At neck	43
From breech	56
Maximum diameter of gun	41
Diameter of—	
Exterior of steel tube	15.5
Powder chamber	12.30
Shot chamber	12.155
Bore	12
Length of—	
Powder chamber	17.25
Shot chamber	14.72
Total length of—	
Bore, including chamber	192
Gun	224
Number of grooves (to be increased experimentally, probably to 21)	7
Depth of grooves	.01
Width of grooves	.9
Width of lands	4.5

Twist, 1 turn in 70 feet; weight of powder charge, 120 pounds; cost of gun, $28,500. (*Vide* Report of 1872, p. 138–178, and model of gun plant inside of building.)

Solid gas-check for Thompson gun.—A bronze gas-check with a solid base, provided with a central flame hole, for the reception of the primer. The latter consists of a blank metallic cartridge about caliber .25, which by the blow of the firing-pin is dis-

charged into the base of the cartridge. When the gun is fired this cup is expanded against its seat at the base of the bore, and this prevents leakage of gas.

Open gas-check for Thompson gun.—For convenience of placing the gas-check in position and to assist in withdrawing it, the bottom is cut away with the exception of a diametrical bar which contains the primer seat.

No. 9. 10-inch Woodbridge rifle.

A 10-inch rifle, made of 0.3-inch square steel wire, wrapped, under high tension, upon a steel tube until the requisite profile of the gun is developed, then placed vertically in a mould, heated to the melting point of bronze, and soldered or brazed together by melted bronze. Made at Frankford Arsenal, Philadelphia, 1876. (*Vide* report Chief of Ordnance, 1872, pp. 158-176, and model of gun plant inside of building). This gun is slung under the Laidley hydraulic sling-wagon, intended for the transportation of pieces of heavy ordnance. The two pair of wheels and axles are connected by a body consisting of two beams laid on edge and curved so as to follow approximately the profile of the gun. The beams are straight and parallel in their rearmost parts so as to allow the frame containing the lifting jack to be easily shifted if necessary. The hydraulic lifting jack, with its frame, straps, and trunnion rings, serves to lift the gun from the ground by steps of 5 inches at a time, the weight being supported during the lowering of the jack by pins placed through the holes in the straps and resting upon the lower beam of the lifting frame; a 7-ton gun has been slung by one man in two minutes and lowered in five seconds. (*Vide* Ordnance Note No 37.)

This wagon is designed for the transportation of a 10-inch smooth-bore or 8-inch rifle of about half the weight of the gun it now supports. It was deemed expedient, however, to support the gun in this manner so as to economize space and to illustrate the operation of the wagon. To more fully display the gun, the iron foot-boards resting upon the beams which form the body, have been removed.

Ten-inch Woodbridge gun, experimental: Weight, 30,300 pounds; number of grooves, 19; twist, 50 feet; total length, 174 inches; proof charge powder, 70 pounds; weight of shot, 400 pounds; velocity (estimated), 1,350; pressure, 28,000; maximum diameter, 36. Tenacities from specimens on exhibition: body of gun, tangential, 92,510 pounds, No. 24 specimen; body of gun, longitudinal across bronze joint, 24,400, four times, No. 25 specimen; steel tube longitudinal, 85,571.

No. 10. Woodbridge gun; caliber 2.5 inches. Experimental.

Made of one-tenth-inch square steel wire wound about a bronze mandril; the entire mass soldered with bronze and bored out. Weight of gun, 9,000 pounds. Fired over fourteen hundred and twenty-seven times with one pound of powder, 7¾—10½ pound shot. (See Report of Chief of Ordnance 1872, page 170; also model of apparatus for manufacture, and large gun outside.)

No. 11. Model, representing the manufacture of the Woodbridge gun. Scale, 1 inch = 1 foot.

The following description of the manufacture of the large Woodbridge gun applies closely to the reduced model. For further illustration see sample of reel of wire (actual size) with friction tension apparatus used in manufacture; also samples cut from body of gun after manufacture, and test specimens.

This gun consists of a steel core, upon which is wound steel wire until the gun is brought to certain dimensions. The core is a hollow cylinder of steel, 15 feet 9 inches in length and 13 inches diameter, and having flanges shaped like a spool or bobbin, to support the coils of wire, attached to its end. The wire was manufactured under the Siemens-Martin process by Cooper, Hewitt & Co., of Trenton, N. J. It contains about one-fourth of 1 per cent. carbon, is rolled three-eighths inch square, then drawn through dies three-tenths inch square, and annealed in a furnace designed by Dr.

Woodbridge. Oxidation is prevented by the use of carbonic oxide gas injected into the receiver, by which the oxygen is destroyed and the wire left bright after annealing. This is a necessary requirement in the gun construction.

The coils weighed from 36 to 40 pounds each, and were carefully inspected as to size, only .001 of an inch maximum and minimum variation being allowed. A piece was cut off from each end of the coil, and tested by twisting in a machine made specially for this purpose by Dr. Woodbridge. (*Vide* Report Chief of Ordnance, 1875.) The wire was divided into four classes in the order of its strength. The ends, according to classes, were scarped off by milling, and brazed at a gas furnace. The united coils, weighing about 400 pounds, were wound upon reels, twenty-nine of which were placed on a carriage. The strands of each reel were unwound for about 25 feet, and gathered into a receiver, making a band about 9 inches wide. Friction was applied to the wire in the receiver by screws pressing on brass plates, giving the required tension for winding, viz, 2,900 pounds, or 100 pounds per wire. The ends of these twenty-nine wires were then fastened to the core. The object in having so large a number of wires wound at the same time was to give as much obliquity as possible for longitudinal strength. Thirty-eight layers of wire were wound to give the proper diameter of 36 inches, arranged in off-sets from the muzzle to the breech, to give the required contour. The ends of the last layer of wire were fastened to the core flange.

The elements of the strands of wire were in close contact with each other, being driven up tight by hand in winding.

After winding the spool, it was placed in a tight iron case, made of boiler plate in two parts screwed together, and fitted as close to the shape of the mass within as was possible. At the bottom of this case was a trap or entrance, closed by a bronze plug. This case, containing the spool, was placed in a specially constructed vertical heating case. The heat for this, generated by a connecting furnace at the top, passed over and around the iron case to the bottom, and escaped through an interior flue at the top.

By an extension of the interior tube an opportunity was found to arrange three heat indicators in the shape of bronze rods. These reached, one to the bottom, another to the middle, and the third to a point half way up the chase.

On the ends of these rods were fixed bronze plugs and a counter-balance weight, which, falling when the rods melted, indicated that the interior had arrived at the proper heat.

The melted bronze was run in from an adjacent furnace, and entering through the trap at the bottom, worked upward to the muzzle, filling up all the interstices of the wire to the core, and driving out all the gases at a vent made at the top when the pouring commenced.

After the pouring, the exterior of the containing case was found coated with bronze about one inch thick, this being the space allowed between it and the heating case for the downward passing of the heat. The pressure at the bottom of the flask was about 90 pounds to 1 square inch.

After the pouring the heat was continued across the top, to keep the metal in a fluid state so as to supply the shrinkage at the breech, which was being cooled by an air-blast from the interior. When cooled the casting was removed to the lathe and finished in the same manner as other ordnance.

The great difficulty in the manufacture of this gun was to heat so large a mass to the proper degree without oxidation or injury to the metal. This was successfully accomplished in every respect, provision being made to estimate and regulate the heat and test the character of the gases. Charcoal was the fuel used.

The turning of the gun in the lathe showed the metal to be most thoroughly annealed. The boring and rifling showed only .001 of an inch variation.

Inside strength of wire, 90,000 pounds to the square inch; length of gun, 174 inches; length of bore, 155 inches; maximum diameter, 36 inches; diameter of trunnions, 11.75 inches; weight, 30,300 pounds; preponderance, 100 pounds.

STEEL TUBE.

	Specific gravity.	Tensile strength.
		Sq. inches.
Tangential	7.8594	88.845
Longitudinal	7.8656	85.480

BODY OF GUN.

	Specific gravity.	Tensile strength.
		Sq. inches.
Tangential	7.8980	91.288
Longitudinal (brazing)		24.400

No. 12. 9-inch breech-loading rifle, Sutcliffe. Experimental.

The gun consists of an iron body, cast on the Rodman plan, lined with a jacketted steel tube, which was inserted by hydraulic pressure, and secured in position by a muzzle collar and the abutment of the pocket against a shoulder in the casing. The breech-loading part consists of a disk-shaped breech-block, supported on a pin attached eccentrically to the front end of a hollow breech-screw, by the half revolution of which the block is lowered into a mortise in the body of the gun and the chamber exposed. The gun is loaded through the hollow screw. To assist in opening the breech, the head of the hollow screw outside the gun is surrounded by a circular rack of gun-metal worked by a pinion fastened to the gun. In case of jamming or sticking after the discharge, handspike holes are made in the periphery of the head.

Chassis.—The chassis is provided with Sinclair's friction recoil check. The recoil is checked by the friction of compression plates on the upper and lower surfaces of a slightly wedge-shaped iron strap. At the rear end this strap is provided with a rubber washer to prevent the tendency toward "buckling," due to the counter recoil. One man can open this gun with ease.

Top carriage.—The gun is elevated by means of two geared arcs, whose center is in the axis of the trunnions, and into which mesh pinions are driven by cranks outside the carriage.

The carriage is moved either way along the chassis by means of a counterpoise handspike with an adjustable pawl. The rear axles are eccentric as in the 20-inch gun. This carriage is essentially the standard carriage for the 15-inch gun. The friction plates are set against the vent just before firing by a clamp screw.

(*Vide* Ordnance Notes No. 33, Report of Chief of Ordnance, 1874, p. 133, plate 7. Platform, see 20-inch gun.)

Weight of Sutcliffe 9-inch gun	pounds	44,800
Weight of charge	do	45
Projectile, lead coated, similar to those used in the Krupp gun	do	230
Exterior diameter of gun at muzzle	inches	21.12
Maximum diameter	do	47.38
Diameter of bore	do	9.00
Diameter of chamber	do	9.30
Diameter of breech-block	do	16.50
Diameter of screw, with threads	do	18.00
Diameter of screw without threads	do	16.50
Diameter of interior of breech-screws	do	9.70
Diameter of vent	do	0.20
Thickness of tube, greatest	do	3.75

Thickness of tube, least	inches..	2.625
Total length of cast-iron part	do....	183.40
Length of rifled portion of bore	do....	———
Length of breech-screw, including shoulder	do....	28.50
Length of breech-block	do....	12.40
Number of lands		36
Number of grooves		36
Depth of grooves	inch..	0.09
Width of lands at muzzle	do....	0.2920
Width of lands at chamber	do....	0.3920

Twist, one turn in 60 calibers, or 45 feet; the chamber is eccentric with the bore; preponderance, nothing.

The tube was manufactured by Firth & Sons, Sheffield, England, and was forged from a solid ingot and tempered in oil; velocity, 1,409 feet; pressure, 28,500 pounds; tenacity of cast-iron from specimens on exhibition, 33,000 pounds.

No. 13. Model of plant (apparatus) for 9-inch Hitchcock gun; construction experimental; scale, 1 inch = 1 foot. (*Vide* Report Chief of Ordnance, 1872, p. 74.)

The gun is composed of consecutive disks of wrought-iron, welded together face to face, so as to form, when completed, a pile like that of a roleau of coins. The disks are of varying diameter, so as to give the completed mass the approximate contour of the gun. (See wooden model of roughly-finished gun.) The peculiarity of this system consists in the fact that any two adjacent pieces are welded together in *the furnace*. This precaution is sought to avoid the oxidation of the surfaces likely to occur in the open air and the imperfect welding likely to result therefrom. To carry out this plan a large opening, closed by a movable lid, is left in the crown of the welding furnace, directly beneath the hammer. Through this opening, at the proper time, the hammer falls upon the pieces to be welded. The other furnace is the heating furnace. This receives and heats the loose disk intended to be joined to the series of disks already welded into the body of the gun in the welding furnace. When sufficiently hot the disk is drawn out of the furnace door, caught beneath its middle by the tongs, and lifted by cranes. The position of the center of gravity causes the disk to revolve in the tongs, bringing the upper (hot) side down. Large pieces are first turned over in the furnace and then drawn out. The crane then transfers the disk to the welding furnace, where it is laid on top of the rest of the gun, the upper surface of which has been, meanwhile, heating independently. Having been centered by a skeleton double cone, entering the holes previously left in each disk, the crane is withdrawn, the furnace covered, and the upper pieces allowed to recover any heat lost in the transfer. The two pieces are kept apart in this heating and the flame allowed to pass between them by the insertion of three blocks of wrought iron between their contiguous surfaces. The lid is again swung aside and the hammer allowed to fall as often as may be necessary to unite the pieces solidly together. Then, as the piece last set on projects at least its own thickness above the floor of the furnace, the entire gun is lowered to that amount by withdrawing the water from the hydraulic cylinder in which the anvil rests. This lets down the upper disk, so that its former lower side now becomes the upper side, is level with the floor of the furnace, and ready for a fresh heat. A repetition of this process builds up the gun.

The peculiarities of construction are as follows: The foundations for the furnace, for the hammer, and for the anvil, are all independent of each other. The hydraulic cylinder rests upon a large cast-iron base supported, for the sake of elasticity, by coarser timber work resting upon solid rock. The cylinder is of cast-iron, banded with wrought-iron rings, into which a force-pump drives water, which may be allowed to escape by suitable cocks. Resting in the cylinder is the pneumatic anvil,

consisting simply of a piston reaching far down into the water and having the portion immersed cored out so as to form an air-chamber. Air can be supplied to this chamber or withdrawn from it by means of a hand air-pump (not in the model). This inclosed air forms a cushion which relieves the hydraulic cylinder from the shock of the hammer when it falls. The effect in practice is very remarkable. Above this piston is a series of cast-iron anvil blocks piled up above each other, very much in the manner of the elements of the gun, with which, however, they should not be confounded. A section of these, equal in length to the lift of the pneumatic anvil, is removed each time the lathe is run down to its limit. They are replaced in lifting the gun out of the pit after its completion. The superincumbent weight is supported by bars resting across the pit in changing. The arrangement of gearing shown permits the iron column to be slowly turned while heating, to expose the disk upon its summit equally to the flame. A similar arrangement is provided in the heating furnace; also a lever, by which the disk can be raised from the water bottom on which it rests to be turned over. This water bottom is of boiler-iron, and is filled with running water; it is designed to prevent the disk from softening too much by confining the heating to its upper surface. Experiments with the original construction were not sufficiently prolonged before the appropriation for their continuance reverted to the Treasury, to afford the experience necessary to construct a cannon upon this principle. The plant is now standing at the National Armory, Springfield, Mass., where this model was made.

No. 14. Air pump and reservoir for use with Hitchcock model.

The pump, which is kept in constant operation, is driven from the shafting used in the rifle manufacture. It keeps up a steady pressure of 7 pounds per square inch in an ale keg buried in the ground near the model of the gun plant. This keg has a safety-valve, and a direct communication with the cylinder of the "steam" hammer. This happens to be an anticipation of one of Mr. Hitchcock's plans. He proposes to use air in future constructions instead of steam for his hammer, to avoid the loss of fuel consumed in keeping up a head of steam for only occasional use.

No. 15. Dank's iron, from Graff, Bennett & Co., Pittsburgh, Pa.

The samples represent the material used in the construction of the Hitchcock gun (see model of plant), in its various forms. First, the sponge, as it leaves the Dank's rotary puddling furnace. This sponge, weighing 2,905 pounds, is supposed to be the largest puddle ball ever made in the United States. Next is the puddle ball partly rolled or cogged in the squeezer, weigh 1,995 pounds; then a smaller one, after the squeezing is finished, weight 1,617 pounds. This is called a bloom. Then a bloom broken to show the fracture, weight 1,315 pounds. These blooms, after heating, were flattened out and welded together in pairs until they formed a mass large enough for one of the constituent disks of which the gun was composed. This iron has been rolled out to the $\frac{1}{125}$ part of an inch in thickness without breaks; its tensile strength is about 57,000 pounds per square inch. Various specimens are shown, punched, bent, and twisted cold.

No. 16. 8.4-inch Mann breech-loading rifle. Made at Trenton, N. J., in 1863.

The gun consists of a cast-iron body, recessed back of trunnions so as to allow a series of iron bands to be shrunk on from there to the breech. The breech is opened and closed by means of a transverse crank-shaft operated by gearing from without, which passes under the gun, and has the crank playing in an enlongated eye formed in a lug beneath the breech of the gun. As this eccentric turns it alternately raises and depresses the breech of the gun and so opens or closes it. The gun revolves on its trunnions, the breech-piece and straps remaining stationary, and being sustained against the discharge by straps passing around the trunnions. The whole gun may

be elevated or depressed by means of the two vertical screws connected with the breech-piece which gear into an endless screw worked by a crank from the side. The gun is screwed up when closed by means of a screw passing through the breech piece, and moved by means of the weighted lever outside; this lever travels loosely upon the body of the screw, and bears at pleasure against either one of the stops upon the screw. It may be swung forcibly against these stops, giving a shock to the screw, either to assist in starting it back or to set it firmly home. (*Vide* Report Chief of Ordnance 1872, p. 108.)

The carriage is only peculiar from being cut away so as to allow the descent of the extremities of the crank-shaft. It is provided with a front eccentric axle for throwing it into rolling friction.

Weight of gun, 20,000 pounds; weight of shot, 168 pounds; weight of powder, 30 pounds; velocity, 1,406; pressure, 25,500 pounds; number of grooves, 11; twist uniform, 1 turn in 60 feet; length of bore, 12 feet; maximum diameter, 28½ inches; side straps, 11 by 4½ inches.

Steel gas-check for Mann 8.4-inch breech-loading gun.—The expansion of the gases presses the edges of the ring against the sides of the chamber and thus prevents the escape of gas to the rear.

No. 17. 8 inch muzzle-loading rifle.

A rifle converted from a 10-inch Rodman cast-iron smooth-bore, by lining with a jacketed wrought-iron coiled tube inserted at the muzzle. (*Vide* Report of Chief of Ordnance, 1872, p. 62; do. '75, p. 97, and Ordnance Notes No. 33.)

Carriage.—To meet the preponderance (forward) of this gun, caused by the change in the center of gravity due to the lining tube, it is held upon its proper carriage by geared arcs, as in the Sutcliffe gun. To economize space, however, in this particular instance, the gun is mounted upon an ordinary 10-inch smooth-bore (casemate) carriage, provided with two air cylinders (pneumatic buffers). These buffers check the recoil of the piece by means of the resistance which the air they contain opposes to the motion of the piston. A small hole is left in each end of the cylinders to diminish the counter recoil, by filling the vacuum in front of the piston and diminishing the pressure in rear. A wooden and plaster model section of a casemate illustrates the application of this gun, which, from the number of casemates already built to accommodate the 10-inch smooth-bore gun, from which it is derived, bids fair to be extensively used. (*Vide* Report of Chief of Ordnance, 1875, p. 91; Ordnance Notes No. 33; Report Chief of Ordnance, 1874, p. 135.)

Platform and implements. (See description of 20-inch gun.)

Dimensions, etc.

Caliber	inches..	8
Total length of gun	do....	136.66
Length of bore	do....	117.25
Length of rifling	do....	107.25
Diameter of bore including grooves	do....	8.15
Number of lands and grooves	each..	15
Twist uniform 1 turn in	feet..	40
Weight of gun	pounds..	16,160
Charge hexagonal powder	do....	35
Projectile, Butler's expanding, weight	do....	180

Fired, 761 times; velocity, 1,411 feet; pressure, 31,300 pounds per square inch; length of tube, 120 inches; thickness of tube: first, 1 inch for 32 inches, and 2.75 inches, and second 1.75 inches; carriage (top), weight, 2,500 pounds; carriage chassis, weight, 3,500 pounds.

No. 18. Cast of bore of 8-inch rifle.

This cast represents the condition of the entire surface of the bore after 750 fires with 35 pounds powder and 180 pounds shot. It is somewhat remarkable from the slight extent of the erosion near the seat of the charge. Its immunity is considerably due to the excellence of the powder and of the projectile used. (*Vide* Ordnance Notes No. 33, plate iii, iv, vii.) Being mounted upon centers, the inside of the gun can be as closely examined as the exterior.

No. 19. 4½-inch siege gun.

Used extensively in siege operations during the last war and transported with all armies anticipating obstinate resistance. Made of cast-iron and cooled from the exterior in consequence of its small caliber. It is the intention of the Department to make future guns of this class without preponderance.

Weight of gun	pounds..	3,450
Weight of shot	do....	30
Weight of charge	do....	3¼
Velocity	feet..	1,280
Rifling, uniform; number of grooves		11
Twist	feet..	15
Preponderance	pounds..	300
Extreme range with elevation of 10°	yards..	3,265

(*Vide* Benton, p. 185.)

Benton's iron siege carriage and limber.—Weight, 3,440 pounds. An experimental carriage intended to replace the present wooden siege carriage. (*Vide* Ordnance Memoranda No. 9, p. 13; Benton, p. 569.)

The implements consist of six wooden handspikes which are applied by the cannoneers through and under the wheels to run the gun to and from battery, and under the stock to direct it; a sponge and staff; worm and staff; rammer and staff; all of which are transported in battery wagons, which accompany a siege train on the march. The carriage is without elevating screw in consequence of the anticipated omission of preponderance in future construction. The pole-prop is transferred from beneath the splinter bar, as placed in the wooden carriage, to the middle of the pole.

No. 20. 3-inch wrought-iron muzzle-loading rifle.

Made at Phœnixville, Pa., by wrapping boiler plate around an iron bar so as to form a cylindrical mass of a certain diameter. The whole is placed in a furnace and brought to a welding heat and then passed between rollers to unite it solidly together. The trunnions are then welded on and the piece finished to the proper size. (*Vide* Benton, p. 181.)

Carriage.—The carriage is of iron, on a plan devised by Col. J. G. Benton, United States Ordnance Corps. It is designed to secure lightness and strength, and nonliability to overturn, breakage, or loss of the implements. It is provided with a sweep-bar to relieve the necks of the horses from the weight of the pole. By the use of thimbles and washers it can be used either for this gun or the light 12-pounder smooth-bore. The sweep-bar enables the pole-yokes to be dispensed with. The limber and the caisson (outside) are without chests, so as to exhibit fully their construction. (*Vide* Ordnance Memoranda No. 9, p. 12.) Attached to the limber is the model of a horse in carton pierre, provided with the service artillery harness. The main peculiarity of this consists in the attachment of the traces of the lead horses directly to the traces of the wheel-horses, rendering the latter independent of the lead horses. (Benton, p. 218, *et seq.*) Upon the horse is mounted a figure representing a light artillery soldier in full dress, carrying the light artillery saber (Benton, p. 284), and Colt's revolver, caliber .45.

Weight of gun	pounds..	820
Weight of shot	do....	10
Weight of powder	do....	1
Velocity	feet..	1,232
Number of grooves		17
Depth of grooves	inches..	.075
Twist uniform	feet..	11
Extreme range at 20 inches elevation	yards..	3,972
Cost		$450
Weight of carriage without chests	pounds..	1,850
Weight of caisson without chests	do....	1,190

No. 21. 10-pounder Parrott rifle.

A cast-iron gun re-enforced by a coiled wrought-iron jacket shrunk on over the seat of the charge. The other calibers of the Parrott gun used during the war, were the 20-pdr., 30-pdr., 100-pdr., 200-pdr., 300-pdr. The larger calibers were cast hollow on the Rodman principle. Though never adopted as a part of the system of our artillery, they were very largely used.

Cost of gun		$187
Weight	pounds..	890
Weight of shot	do....	10
Weight of charge	do....	1
Diameter of bore	inches..	3
Twist (increasing)	feet..	10
Number of grooves		3
Depth of grooves	inch..	0.1
Extreme range, 15° elevation	yards..	3,558

(*Vide* Benton, pp. 181 and 549.)

Hagner's field carriage for three-inch rifle, made at Watervliet arsenal, and intended to replace the present wooden field carriage.—Implements as in 3-inch rifle and light 12-pounder; weight of carriage and limber without chest, 1,865 pounds. (*Vide* Benton, p. 569.)

No. 22. 2.75-inch Whitworth rifle.

Cross-section of bore is a hexagon with rounded corners, and rifle motion is obtained by giving projectile a like shape. It is made of low steel, forged solid. Presented by loyal citizens, and used in first part of late war.

Diameter	inches..	2.75
Weight of gun	pounds..	1,092
Weight of shot	do....	12
Weight of charge	do....	1¼
Twist	inches..	55

(*Vide* Benton, p. 544, and Abbot's Siege Artillery, p. 104.)

No. 23. 3.15-inch Hotchkiss breech-loading rifle. Expe imental.

Made of steel by Vavasour & Co., London, a breech-block, sliding at right angles to the axis of the bore and locked when closed by a sectional screw within the block. The gun is remarkable for the high charges it fires in comparison with its caliber and weight.

The powder is contained in a metallic cartridge case, either of wrapped metal or with a soldered joint. Through the center of the head of this case is a flame hole closed by an internal valve, which is lifted by the flame from the friction primer, but is closed by the pressure of the gas within the bore when the cartridge is fired. Above the breech-block in the body of the gun is a sliding extractor, which is worked by an oblique groove in the upper surface of the breech-block, in which a stud on the

lower surface of the extractor is engaged. When the breech-block is quickly drawn out the extractor is slid back, carrying with it the empty cartridge case. The position of the extractor protects it from dust, dirt, &c.

Weight of gun, 1,000 pounds (approximated); weight of shell, 11.5 pounds; weight of powder, 2.5 pounds; initial velocity, 1,465 feet.

No. 24. 1.65-inch Hotchkiss mountain cannon.

Works upon exactly the same principle as the large cannon; used in operations in a very rough or mountainous country, impassable to wheeled vehicles.

Caliber, 1.65; number of grooves, 12; depth, .0075 inch; width, 30; weight of gun, 110 pounds; charge of powder, 25 grams, 269.5 grains; weight of shot, 900 grams, about 2 pounds.

No. 25. 3.09-inch Moffatt breech-loading rifle.

The Moffatt breech-loading field gun; caliber, 3.09 inches; manufactured at the South Boston foundry; made of crucible cast steel, the body of the gun being forged from a single ingot. The gun is opened by means of a lever shown alongside, and also shown assembled in a model of the gun. (See models of gun-carriages.) The depression of this lever throws down the breech-piece, carrying with it the breech-plug by means of a leather strap connecting them. The breech-plug is hinged to a lug on the under side of the gun, and the breech-piece revolves on the trunnions of the gun, being connected with them by two side straps forming part of it. The piece is closed by converse means. It is held closed by means of a short screw passing through the breech-piece and entering a recess in the back of the breech-plug. The escape of gas is prevented by a brass gas-check, like the Broadwell ring, set in a recess in the mouth of the chamber.

Dimensions.

Length of bore	inches..	65.50
Length of rifling	do....	55.00
Length of chamber	do....	9.50
Length of beveled junction of chamber and bore	do....	1.00
Number of grooves and lands		12
Width of lands	inches..	0.25
Depth of grooves	do....	0.05
Twist, uniform, one turn in 12 feet.		
Weight of gun, about	pounds..	900
Diameter of chamber	inches..	3.19
Diameter of bore across lands	do....	3.07
Exterior diameter of gun at muzzle	do....	5.90
Exterior diameter, maximum	do....	9.57

Preponderance of the gun is such as to render the gun easily operated.

Projectiles.—Lead-coated and Butler's breech-loading projectile with double bearings. Weight from 9½ to 10 pounds; charge of powder (mortar), 1¼ pounds; velocity, 1,120 feet; pressure, 20,000 pounds.

No. 26. 3-inch Mann breech-loading rifle.

Opened by withdrawing set screw through the breech-piece until free, and then turning forward the crank handle on the right side of the gun. This operates a crank beneath the gun, which causes the side straps, surrounding the trunnions and supporting the breech-piece to fall. In this case the body of the gun remains stationary and the straps and breech move, instead of the converse being the case, as in the large 8.4-inch Mann gun. This gun uses a gas-check either of bronze or of composition, somewhat resembling the Broadwell ring. When closed the eccentric rod or crank lies directly beneath the body of the gun, embracing it, so that there is no tendency for it to open.

(*Vide* Report 1872, p. 110.)

No. 27. Sutcliffe 3.15 inch breech-loading rifle. Experimental.

Constructed at the West Point foundry from a 3 inch wrought-iron muzzle-loading rifle. Disk-shaped breech-block supported on a pin attached to front end of hollow breech-screw, by the half revolution of which the block is lowered into a mortise in the body of the gun and the chamber exposed. A brass cup protects the lower opening of the mortise from exposure and injury. (*Vide* Report 1872, p. 127.)

Projectile.—Butler's expansive projectile for breech-loaders; flared sabot; weight of shot, 10¼ pounds; shell, 10 pounds; powder-charge, 1¼ pounds; velocity, 1,110 feet.

Dimensions, etc.

Diameter of bore across lands	inches	3.15
Diameter of bore through	do	3.25
Diameter of chamber	do	3.25
Number of grooves		11
Depth of grooves	inches	0.05
Width of lands and grooves	do	0.45
Twist, one turn in 11 feet.		
Weight of gun complete	pounds	800
Weight of shell	do	10
Weight of powder, mortar	do	1¼
In velocity of projectile	feet	1,165
Pressure		

No. 28. Vandenburgh volley gun; obsolete; caliber, 4.6 inches; weight, 663 pounds.

Proposed for use during the war of the rebellion. The 86 copper-lined chambers in the breech-piece were supposed to be loaded in detail, for a simultaneous discharge. Carriage weight, 690 pounds.

No. 29. Requa battery; caliber, .53. Obsolete.

For simultaneous discharge of 25 barrels. The barrels were loaded at the breech with paper ammunition. Failed for want of a proper gas-check. Used at the siege of Fort Wagner, South Carolina.

No. 30. Guthrie & Lee; caliber, .45. Obsolete.

The two barrels are fixed to the frame of the gun. At right angle to their length travels a chamber-piece, to which, by the action of the hand lever, a reciprocal motion is given when the chamber is protruded beyond the line of the frame. It is loaded by hand. When brought back in line with the barrel the charge is fired by a concealed lock. The pair of loading troughs and pistons attached to each barrel are interesting pieces of mechanism. No record of this gun is accessible. Weight of gun, 281 pounds; weight of carriage, 166 pounds.

No. 31. Union repeating (coffee-mill) gun; caliber, .58. Obsolete.

Short sections of muzzle-loading musket-barrels are loaded beforehand and supplied through the hopper upon a fluted cylinder. They are fired successively, and afterwards can be reloaded. One lock used for all the 8 barrels, which stop in their revolution to allow the discharge. After firing the cartridge-cases roll out of their own weight into a receptacle attached to the gun. This gun was used somewhat at the siege of Petersburg, Va.

No. 32. Gatling gun, short barrel; caliber, .45; uses service cartridge.

The cartridges, falling into the hopper from the feed-case (holding 40) during the revolution of the barrels, are successively passed into the chambers by the recipro-

cating motion of the locks, and fired and extracted successively at certain points, making ten shots per revolution. Each barrel has an independent lock which can be injured or removed without interfering with the rest. An automatic oscillator permits any required divergence to be given to the shots.

Cost of gun		$1,000
Weight of gun	pounds	138
Weight of oscillator	do	210
Weight of cartridges	grains	630
Weight of ball	do	405
Weight of charge	do	70
Velocity	feet	1,201

Gatling gun, caliber .50; fired at target 24 by 6 feet, at 900 yards, 393 shots, 309 hits, in one minute and nine seconds.

(*Vide* Ordnance Memoranda No. 17, Report 74, Appendix F, p. 15.)

No. 33. Cavalry carriage for Gatling gun; caliber, .45; short barrel.

A special cart with shafts, carrying the gun on an iron frame between two side chests for ammunition. It is drawn by two horses abreast, one in shafts, one under saddle. Weight of cart with gun frame, 790 pounds; weight of gun, 198 pounds; weight of cart with gun and cartridges, 1,416 pounds.

The shaft horse draws on the off side and is attached by hooks pending from the cart saddle passing through eye-bolts in shafts; he is instantly detached by releasing these hooks. The riding horse carries traces and is attached to near side of cart by a single-tree hooked to ring-bolt. When detached from cart, the single-tree is hooked to an eye-staple on cantle of the riding saddle (without unhitching traces). The horses thus rapidly removed upon coming into battery, the shafts fall to the ground and form the trail of the carriage, which is further steadied by dropping the forked prop before firing.

Rounds of ammunition carried in two side chests, carrying each 24 feed cases with 40 cartridges each	1,920
In front box (under axle) two boxes of cartridges in packages of 1,000 each	2,000
Total rounds	3,920

(Ordnance Memoranda No. 18, p. 39.)

No 34. Cavalry forge-cart.

Attached to company of cavalry; carries smith's bellows and fire-box in one compartment (movable); coal-box (fixed); smith's tool-box (movable); farrier's and first sergeant's box (fixed), for medicines and extra ammunition; box for horseshoes, nails, and iron (fixed); box for harness maker's tools and leather, and for leather tool bags (fixed); cart is drawn by two horses abreast, one in shafts; weight of cart, 1,203 pounds. It is intended, when in quarters, to remove the movable boxes within doors, placing the bellows and fire-box on any stand convenient for the smith's use.

Another cavalry forge-cart, somewhat lighter in weight, having a fan blower instead of the hand bellows, is under trial in the field.

(Ordnance Memoranda No. 18, p. 68.)

No. 35. Hotchkiss revolving cannon. Experimental.

By the revolution of the barrel a cartridge inserted at the hopper above is transferred in front of firing-pin. The barrels then remain at rest long enough to permit the cartridge to be fired, and revolving again carry this empty cartridge to the extractor below, where it is drawn out and falls to the ground. A repetition of this process enables this gun to fire from sixty to eighty shots per minute. The operations of loading, firing, and extracting are all done during the momentary intermittent pauses of the barrels, and by a single set of parts which answer for all five barrels.

Weight	pounds..	1,157
Caliber	inches..	1.456
Number of barrels		5
Number of grooves		12
Twist	inches..	49
Weight of shell	grains..	520
Weight of shot	pounds..	1¼
Weight of charge	ounces..	3

Fires special cartridges; range, elevation 35°, 5,468 yards.

No. 36. Hotchkiss mitrailleuse; caliber, .62.

Exactly like the large repeating cannon, except in the rapidity of its fire, this gun being geared so as to fire about one hundred and fifty shots per minute.

Number of barrels		9
Length	inches..	32.75
Number of grooves		7
Depth of grooves	inches..	0.02
Width of lands	do....	0.078
Twist, 1 turn in	do....	29.5
Weight of gun	pounds..	726
Weight of gun with carriage and traversing apparatus	do....	1,760
Charge of powder	grains..	385
Weight of ball	do....	1,543
Weight of cartridge	do....	2,464
Length of cartridge	inches..	5.5

No. 37. Cast-iron 3¾-pounder. Experimental. Bomford and Wade.

Used by these officers of ordnance in 1841 to determine the proper exterior form of cannon by observing the velocity with which balls of standard weight were projected from successive points along the line of the bore. The steel screw-plugs were perforated and shot out a steel pistol-ball into a small ballistic pendulum. As was the observed velocity at any point, so was the thickness of the cannon proportioned. These experiments served to determine the form of the columbiads, model 1842, which with slight changes of form and the introduction of the Rodman method of casting, have since become our standard patterns of heavy smooth-bore ordnance. (*Vide* Benton, p. 152.) These experiments were repeated in Europe by Cavalli, in 1843. Caliber, .3; weight, 936 pounds.

No. 39. Six-pounder bronze, with Woodbridge oil pressure gauges.

This gun is pierced at intervals along the line of the bore, for the insertion of pressure gauges, the action of which depends upon the compressive quality of oil. The amount of compression was noted upon a smoked iron wire projecting into the oil from a movable piston which was exposed to the gas pressure. This pressure drove the piston forward against the oil, compressing it to an extent corresponding to the amount of the pressure. The motion of the piston was measured by a stationary pointer, which scratched the wire as it was driven forward, an ordinary charge produced a compression of about one-half inch, corresponding to about 20,000 pounds per square inch. It is believed that this was the first effort to obtain directly the pressures in the bore of a gun. Date, 1855. Previous attempts had been made to obtain them indirectly by means of velocities.

No. 40. Bronze breech-loader 1½ inch, date, 1570. From New Orleans, La., through the kindness of Messrs. Morris Wheeler & Co., Philadelphia.

This gun is similar to some used by Cortez in the conquest of Mexico, and is probably a relic of the Spanish occupation of that country. Breech-loaders were

common in the earlier forms of artillery and this form was one of the most frequent. The charge was contained in a hollow tube with a handle like a flat iron, by which it was placed in position. This tube or chamber had projections below it, and in rear which with the assistance of a key driven through the mortises in the side of the piece above it held it in place.

No. 41. Ancient iron cannon, about 6-pounder, dated 1763.

Dredged from bed of Delaware River, near Fort Delaware. The sectoral rim bases are peculiar. Contributed by Colonel Kurtz, United States Engineer Corps.

No. 42. Four bronze 2½ pounders, named "San Mateo," "San Lucas," "San Marco," "San Juan." From Saint Louis Arsenal.

Supposed to have formed part of a battery called the 12 apostles, a relic of the Spanish occupation of Louisiana.

No. 43. Six 6-pounder Revolutionary cannon (2 long and 4 short), supposed to have been presented by Lafayette. From Watervliet Arsenal.

The ornamentation of these is very elaborate and amply repays examination. They are set upon their muzzles, forming, with several sections of chain, an inclosure for the exhibition of the modern Rodman, Hitchcock, and Woodbridge plants.

No. 44. Twelve-pounder Gribeauval siege carriage and avant train.

Used in the Revolutionary War at the battle of Saratoga. The tires are made in sections so as to facilitate their repair when necessary. The bronze gun is merely intended as an accessory to completely illustrate the representation of the carriage.

No. 45. Eight-inch bronze howitzer, Revolutionary, made by J. Byers, Philadelphia, 1777. No. 1.

This howitzer bears, according to the British custom of the time, the armorial crest of Mercer, who was then master general of the ordnance. This was not suited to the temper of the times. See 24-pounder howitzer. Byers No. 2.

No. 46. Five 24-pounder howitzers, Byers, Philadelphia, 1777.

Four of these assist in forming the inclosure for the models of the plant of heavy modern ordnance. One of these bears, in apparent reference to the recently abandoned custom of placing the arms of the master general of the ordnance upon cannon, the device, the "People"; also, "Auspice Deo" and "Liberty."

No. 47. Nine 3-inch 5-pounder howitzer, Revolutionary, made by D. King, Germantown, Pa.

Supposed to have been experimented with by "Mad" Anthony Wayne, and to have been intended to be fired from mule-back. These have always been known as Anthony Wayne howitzers.

No. 48. Two 10 inch mortars, bronze, Revolutionary.

Supposed to have been presented by Lafayette. Beside their generally elaborate carving may be seen the interlaced "L's" the monogram of the French King. These are used to complete the inclosure for the models of modern gun plant.

No. 49. Rebel breech-loading rifle gun. Williams. California, 1.56.

Operated by turning a crank on the right side. Upon the crank shaft are two eccentrics which successively withdraw the breech block so as to expose the chamber of the gun and cock the hammer upon the left side. These eccentrics are so ar-

ranged that just as the breech block is passed forward into place to close the breech the hammer falls and fires the piece. The breech block is supported against the shock of the discharge by its eccentrics, which transfers the strain to shaft upon which it revolves. The piece is fired by a percussion cap. No provision for gas check.

No. 50. Rebel bronze breech-loading rifled howitzer or field piece. Caliber, 1.52.

Breech closed by block revolving on an axis parallel to axis of the bore and beneath. The block is held against the force of the discharge by a bolt, screwed into the gun above the chamber, which passes through a circular slot in the breech block and against the head of which the block is brought to bear by the explosion. This bolt and the axis bolt support it. A lock is attached to the breech block. This piece fired a metallic cartridge with a common cap as primer.

No. 51. Rebel bronze breech-loading rifled howitzer or field piece. Caliber, 2.03.

Breech closed by a flat bar revolving upon and to the right of it. An axis parallel to axis of the bore. There is no provision for a gas check. The bar is held when down by being notched to receive the body of another bolt on the other side of the breech, against the head of which it is pressed by the discharge.

No. 52. Breech-loading rifled boat howitzer or field piece. Caliber, 1.52.

Breech closed by axial plug which is slotted to receive a pair of folding wedges. These are joined by a toggle joint outside the piece, which is operated by a hand lever and which serves to tighten the breech plug in place. The forward end of the breech plug has a conical bearing to prevent the escape of gas. History unkown; supposed to be of rebel origin.

No. 53. Model 15-inch smooth-bore muzzle-loading Rodman gun. Mounted on barbette carriage. Scale 2 inches to 1 foot.

Complete, with implements and equipments to scale. This model is one of those first adopted; several modifications have since been made as to the eccentric axles, maneuvering wheels, &c.

No. 54. Model 10-inch smooth-bore muzzle-loading Rodman gun. Mounted on a casemate carriage. Scale 2 inches to 1 foot.

See remarks model of 15-inch gun on barbette carriage.

No. 55. Model of 13-inch sea-coast mortar. Mounted on center pintle chassis with eccentric axle. Scale 3 inches to 1 foot.

This model is complete in every respect. By throwing the middle eccentric axle into gear, the chassis can be easily traversed. The arms fastened to the ends of the trunnions are used with the socket handspike for elevating. The ends of the mounting bail fit into the holes cut in the trunnion for their reception. See mortar outside and description.

No. 56. Model of mortar wagon.

No. 57. Model of casemate truck.

No. 58. Model of store truck.

No. 59. Model of Gatling limber.

No. 60. Model of sling cart.

No. 61. Model of sling cart, hand.

No. 62. Model of battery wagon.
No. 63. Model of handcart.
No. 64. Model of 8-inch siege howitzer mounted.
No. 65. Model of 24-pounder flank defense howitzer, mounted.
No. 66. Model of 4.5-inch siege rifle, mounted.
No. 67. Model of light 12-pounder, mounted.
No. 68. Model of 24-pounder howitzer, mounted.
No. 69. Strength of materials used in construction of heavy cannon.

1. Woodbridge 10-inch rifle, tangential specimen. Density, 7.8820. Tenacity, 91,514 pounds per square inch.
2. Woodbridge 10-inch rifle. Density, 7.9081. Tenacity, 88,978 pounds per square inch.
3. Steel tube Woodbridge 10-inch rifle. Density, 7.85-2. Tenacity, 85,385 pounds per square inch. Longitudinal.
4. Wrought iron from Dank's rotary puddler. Density, 7.6912. Tenacity, 57,247 pounds per square inch.
5. Steel tube. Density, 7.8730. Tenacity, 85,576 pounds per square inch. Longitudinal.
6. Steel tube. Density, 7.8582. Tenacity, 85,385 pounds per square inch. Longitudinal.
7. Tangential specimen. Density, 7.9081. Tenacity, 88,978 pounds per square inch.
8. Steel tube. Density, 7.8730. Tenacity, 85,576 pounds per square inch. Longitudinal.
9. Steel tube. Density, 7.8730. Tenacity, 85,576 pounds per square inch. Longitudinal.
10. Tangential specimen. Density, 7.8820. Tenacity, 91,514 pounds per square inch.
11. Steel tube. Density, 7.8656. Tenacity, 89,316 pounds per square inch. Tangential.
12. Steel tube. Density, 7.8656. Tenacity, 89,316 pounds per square inch. Tangential.
13. Tangential specimen. Density, 7.8925. Tenacity, 92,160 pounds per square inch.
14. Tangential specimen. Density, 7.8925. Tenacity, 92,160 pounds per square inch.
15. Specimen from wrought-iron tube for lining guns. Tested for density, tenacity extension, restoration, and permanent set.
16. Same as No. 15.
17. Steel specimen from 9-inch converted rifle. Density, 7.8634. Tenacity, 72,000 pounds per square inch. Extension, restoration, and permanent set.
18. Wrought iron from Dank's rotary puddler. Density, 7.6995. Tenacity, 5-,80 pounds per square inch.
19. Same as No. 15.
20. Wrought-iron from Dank's rotary puddler. Density, 7.6912. Tenacity, 57,247 pounds per square inch.
21. Same as No. 15.
22. Same as No. 18.
23. Steel specimen from 9-inch converted rifle. Density, 7.8582. Tenacity, 90,885 pounds per square inch. Extension, restoration, and permanent set.
24. Woodbridge 10-inch rifle, tangential specimen. Density, ——. Tenacity, 92,510 pounds per square inch.
25. Woodbridge 10-inch rifle, longitudinal specimen. Tenacity of bronzing, 24,400 pounds per square inch.
26. Woodbridge. Same as No. 25.
27. Same as No. 25.

28. Same as No. 25.
29. Same as No. 25. Tenacity of bronzing, 21,950 pounds per square inch.
30. Cast-iron specimen, for density and tenacity.
31. Same as No. 30.
32. Same as No. 30.
33. Steel specimen from 9-inch converted rifle. Density, 7.8794. Tenacity, 74,000 pounds per square inch. Extension, restoration, and permanent set.
34. Same specimen as No. 33. Density, 7.8534. Tenacity, 73,000 pounds per square inch.
35. Steel tube, Woodbridge 10-inch rifle. Density, 7.8730. Tenacity, 85,576 pounds per square inch. Longitudinal.
36. Wrought-iron specimen for extension, restoration, and permanent set.
37. Same as No. 36.
38. Same as No. 36.
39. Cast-iron specimen for crushing.
40. Cast-iron, crushing weight of 73,000 pounds applied.
41. Sutcliffe, B. screw. Firth steel, S. 2. Density, 7.8591. Tenacity, 104,087 pounds.
42. Ten-inch shot. Fort Monroe, No. 4. Density, 7.279. Tenacity, 18,371 pounds.
43. Fifteen-inch gun, No. 556. Density, 7.2673. S., 29,473. S. F. November 13, 1866.
44. Richmond test bar cupola, No. 3. Tenacity, 187,000 pounds.
45. 10-inch shot, Fort Monroe, No. 5. Density, 7.274. Tenacity, 18,884.
46. Sutcliffe, B. block, Firth steel, B. Density, 7.8663. Tenacity, 89,996 pounds.
47. Ten-inch shot. Fort Monroe, No. 3. Density, 7.288. Tenacity, 22,231 pounds.
48. Sutcliffe, B. screw. Firth steel, S. I. Density, 7.8437. Tenacity, 104,864 pounds.
49. 9-inch converted gun, steel tube, A. 2. Density, 7.8582. Tenacity, 90,085.
50. Same as No. 49.
51. Shot. Fort Monroe. No. 2. Density, 7.288. Tenacity, 22,580.
52. 9-inch converted gun. Steel tube, A. Density, 7.8598. Tenacity, 88,386.
53. Sutcliffe, B. Block. Firth steel, B. C. Density, 7.8587. Tenacity, 87,164 pounds.
54. Inside Sutcliffe. Density, 7.327. Tenacity, 35,742.
55. Sutcliffe, B. Block. Firth steel, B. Density, 7.8663. Tenacity, 89,996 pounds.
56. Outside Sutcliffe. Density, 7.300. Tenacity, 33,216.
57. Sutcliffe, B. Block. Firth steel, B. C. Density, 7.8587. Tenacity, 87,164 pounds.
58. I 15-inch gun. No. 556. Density, 7.3033. S. 37,4171. S. F. November 13, 1866.
59. American steel. Density, 7.8587. Tenacity, 175,087 pounds.
60. M. 15-inch gun. No. 556. Density, 7.3214. S. 34,136. S. F. November 13, 1866.
61. American steel 148. Density, 7.8367. Tenacity, 139,847 pounds.
62. Sutcliffe, B. screw. Firth steel, S. E. Density, 7,8591 Tenacity, 104,087, pounds.
63. American steel 148. Density, 7.8367. Tenacity, 139,847 pounds.
64. American steel. Density, 7.8367. Tenacity, 175,087 pounds.
65. M. B. Sutcliffe Middle. Density, 7.3026. Tenacity, 31416.
66. M. A. Sutcliffe Middle. Density, 7.3052. Tenacity, 31,469.

No. 70. Laidley gun lift.

The gun is raised by two hydraulic jacks acting upon levers which lift the iron straps attached to the gun. When the superior limit of the hydraulic piston is reached and during its descent for a fresh hold, the weight is supported by a pin passing through one of the lower holds in the strap. The lift is 6 inches. The 15-inch gun, weighing 49,100 pounds, has been mounted with this lift in fifty-four minutes, and dismounted in forty-four minutes. It was used in mounting the 20-inch gun, weight 115,100 pounds, now exhibited. The lift is designed as a portable and effective means of dispensing with the great quantity of blocking usually employed in mounting and dismounting heavy guns.

No. 71. Water bucket.

Made of paper varnished. This bucket is not liable to leakage, nor to falling apart from shrinkage. It is lighter than wood, more durable than rubber, and less expensive.

No. 72. Vent cover.

Secured in place without a strap, having a split spring plug to enter vent. As efficient as the vent cover and strap, while less expensive and more compact.

No. 73. Metallic tompions for cannon and mortars.

Made of sheet iron corrugated, and assembled without riveting. Light, strong, and unchangeable in size by exposure to moisture so that they will not wedge in the guns.

The tompion for use in mortars is readily made to close the muzzle water-tight, by a tie of spun yarn or marline in the groove made for it in the cylindrical part of the tompion, thus calking the joint.

No. 74. Gunner's quadrant.

Consists of a graduated quadrant attached to a brass rule; an arm carrying a spirit level attached to the center of the quadrant, with a vernier at its movable end. It is used in elevating guns and mortars, and applied by resting the rule against the faces of the pieces or against the upper surface of the bore. (*Vide* Benton, p. 256, and Ordnance Manual, p. 132.)

B.—Cannon Ammunition, and Projectiles.

No. 1. Cartridge bags (*filled with sham powder*).

12-inch breech-loading rifle (Thompson). Hexagonal powder, 120 pounds.
9-inch converted muzzle-loading rifle. Hexagonal powder, 45 pounds.
9-inch breech-loading rifle (Sutcliffe). Hexagonal powder, 45 pounds.
8.4-inch breech-loading rifle (Mann's). Hexagonal powder, 30 pounds.
8-inch converted muzzle-loading rifle. Hexagonal powder, 35 pounds.
300-pounder Parrott muzzle-loading rifle. Hexagonal powder, 25 pounds.
3-inch breech-loading field rifle (Mann's). Mortar powder.
3.15-inch breech-loading rifle (Sutcliffe). Mortar powder, 1¼ pounds.
3.09-inch breech-loading field rifle (Moffat). Mortar powder, 1¼ pounds.
3-inch muzzle-loading rifle. Service, 1 pound.

Hotchkiss cartridge. Made of tin soldered hermetically tight. It has a head of sheet iron containing a flame hole through its center. This is sometimes prepared for a metallic primer.

1.63-inch caliber, 6 ounces; 3.14-inch caliber, 2 pounds 13¼ ounces.

No. 2. Bottles containing specimens of ingredients of gunpowder.

1. Crude niter (saltpeter), 5 per cent. refraction.
2. Refined crystalline niter.
3. Refined granulated niter.
4. Refined French roll sulphur.
5. Refined American Virgin Rock sulphur. Almost chemically pure.
6. Willow branches, charcoal.
7. Willow charcoal, red incomplete distillation.
8. Willow charcoal, black, complete distillation.
9. Binary compound: charcoal, 60 per cent.; sulphur, 40 per cent.

No. 3. Standard specimens of United States gunpowder.

No. 1. Mammoth, standard, 1861.
No. 2, 3, 4. Smaller sizes.
No. 5. Cannon, standard, 1861.
No. 6, 7, 8. Smaller sizes.

No. 4. Rebel manufacture, Macon, Ga.

Nos. 1, 2, 3, 4, 5. Mammoth, different sizes.
No. 6. Cannon and mortar powder, mixed.
No. 7. Musket powder.
No. 8. Rifle powder.

No. 5. General Rodman's hexagonal perforated cake powder.

A single cake or grain of powder 5 inches across the face and 2 inches thick pierced with 66 holes about one-quarter inch diameter. See Rodman's Experiments on Metal for Cannon, and Cannon Powder, page 291. Ordnance Notes, No. 35. The powder is designed to burn slowly at first and to continue burning along the sides of the perforations. This enlarges the holes and causes the combustion to take place on a constantly increasing surface, by this means supplying the gas for the vacuum left by the forward moving of the ball. This form of powder starts the shot quietly, and thus reduces the bursting pressure against the sides of the bore. Its hexagonal form is intended to allow it to be compactly arranged in the cartridge in successive tiers as shown by the specimens. Although the invention of this powder marked a very important step in the progress of gunnery, by permitting with safety results formerly supposed to be unattainable, the expense of its manufacture precluded its general adoption. See mammoth powder and prism powder. See Benton, page 153, note.

No. 6. Eight-inch cylindrical perforated cake gunpowder.

See account of hexagonal perforated cake gunpowder. (See Ordnance Notes 35.)

No. 7. Thirty-two-pounder (6.4) cartridge.

Made of cylindrical perforated cake powder disks fastened together by a wrapper of paper pasted on. See account of hexagonal cake powder. (See Ordnance Notes 35.)

No. 8. Round perforated cake powder, 2-inch diameter, one-half inch thick.

In wooden holder to prevent crumbling. See hexagonal perforated cake powder.

No. 9. Perforated cake powder with large interior opening, 4 specimens.

The large opening is designed to assist in the inflammation of the charge.

No. 10. Square perforated cake powder; 5 specimens 2 inches square and three fourths of an inch thick.

In a wooden frame to prevent injury in handling. See hexagonal perforated cake powder.

No. 11. Mammoth powder.

This was the form first adopted by the late General Rodman, for general use in heavy cannon. It answered passably well the conditions of pressure and velocity required and was of much more easy manufacture than the cake powder.

No. 12. Prismatic gunpowder, Russian.

The inconvenience and expense attending the manufacture of the large perforated cake gunpowder, led to the introduction through Russia, of the smaller cake of the

same kind here shown. This is the powder generally adopted in Europe, except in England, where powder of a uniform cubical grain is now employed. See account of mammoth and hexagonal powder.

No. 13. Du Pont's hexagonal powder.

The advantage of this form of grain depends upon its *uniformity* in size, density, and conformation, from which *uniform* results are found to follow in practice. Specimens of (sham) hexagonal powder may be found in any of the filled cartridge bags on exhibition.

No. 14. Square polyhedral powder. Du Pont's, U. S. A., 1873. (See Ordnance Notes III.)

This is a variation from the ordinary form of the hexagonal powder generally used in the United States service.

No. 15. Specimens of musket powder.

1. Prussian needle-gun, Ordnance Board, 1868.
2. United States musket powder, Ordnance Board, 1868.
3. English powder, Ordnance Board, 1868.
4. United States service musket powder, Hazard's, 1876.
5. Swiss, Ordnance Board, 1868.
6. English rifle, fine grain (R. F. G).
7. Chassepot from Liege Ordnance Board, 1868.
8. English fine grain (F. G.) from Woolwich Arsenal.
9. Rebel, Macon, Ga., Ordnance Board, 1868.
10. English boxer cartridge, Ordnance Board, 1868.
11. English large grain (L. G.) from Woolwich Arsenal.

No. 16. Schultz wood gunpowder.

Like gun-cotton except that wood is used instead of cotton for the basis of the composition.

No. 17. Cannon powder.

From the Spanish frigate Arapiles, New York, 1873. Manufactured by John Hall, Deptford, England. This powder is formed in spherical pellets, varying in diameter 0.42-inch to 0.64-inch.

No. 18. English cannon powder.

From H. B. M. S. S. Monarch, 1870.

No. 19. Metallic powder barrels.

Proposed in 1856, to replace wooden barrels, and made *like these examples* at Watervliet Arsenal in 1864. Made of sheet-iron or copper. The body is corrugated by machine, after joining the two halves by laps, and the heads are corrugated and cupped under drops, and secured to the body by folding the edges together and crimping in a milling machine. The hand-hole is closed by a screw-plug of brass, interchangeable, and secured to the head by rivets. The only rivets used in forming the barrel are those in the screw-plug.

No. 20. Smooth-bore projectiles, spherical.

Spherical projectiles used in smooth-bore guns are divided as follows:

Solid shot: Used where penetration and range are required.

Shell: Hollow shot; loaded with bursting charge, and used principally against animate objects, especially when in sheltered positions.

Spherical case: Hollow shot, loaded with musket bullets cemented together with

sulphur, and exploded at any required point of its flight by a small bursting charge; used against animate objects.

Canister: A number of cast-iron balls arranged in four layers, packed in sawdust and inclosed in tin cases with iron ends. It breaks to pieces after leaving the muzzle of the gun and is used against animate objects distant but a few hundred yards.

Grape shot: Composed ordinarily of nine cast-iron balls arranged in three layers and held together either by a canvass covering, or by iron ring and plates united by a rod. Its action and use are similar to those of canister.

Bar and chain shot: Two shots connected by a chain or bar, once used for firing at short distances against the masts and rigging of ships.

Carcasses: Shells loaded with incendiary composition, the flame from which issues through holes and sets fire to wooden buildings. In the field service the projectile and cartridge bag are both attached to a wooden sabot, which is used to prevent the projectile from bounding in the bore; to keep it in its place before firing and to moderate the action of the powder upon it. So prepared, protected by a paper cylinder and cap it is called "fixed ammunition." In the siege and sea-coast service the shell and case shot are attached to sabots, to prevent the fuze from coming in contact with th powder of the charge.

The following spherical projectiles are exhibited.

United States Service.

1. 6-pounder shot strapped.
2. 6-pounder canister strapped.
3. 6-pounder grape; canvas cover; wooden sabot.
4. 6-pounder spherical case; strapped, Bormann fuze.
5. 6-pounder chain-shot; hemisphered, united by chain.
6. 12-pounder shot; fixed.
7. 12-pounder spherical case; fixed, Bormann fuze.
8. 12-pounder shell; fixed.
9. 12-pounder grape; iron rings.
10. 12 pounder canister; long sabot, fixed.
11. (5) 12-pounder mountain howitzer shell, Bormann fuze, fixed.
12. 12-pounder mountain howitzer, spherical case. Bormann fuze; fixed
13. 18-pounder shot.
14. 18-pounder shell, strapped.
15. 18-pounder spherical case, strapped.
16. 18-pounder canister (no sabot).
17. 18-pounder grape.
18. 24-pounder shot.
19. 24-pounder canister.
20. 24-pounder shell, wooden fuze plug.
21. 24-pounder spherical case, Bormann fuze.
22. 24-pounder grape.
23. (2) 24-pounder shot, fixed (dredged from Delaware River).
24. 32-pounder shot.
25. 32-pounder shell, wooden fuze plug.
26. 32-pounder spherical case, Bormann fuze.
27. 32-pounder canister.
28. 32-pounder grape, rings.
29. 42-pounder shot.
30. 42-pounder shell.
31. 42-pounder case-shot.
32. 42-pounder canister.
33. 42-pounder grape, rings.
34. 8-inch shot (wooden model).

35. 8-inch shell; columbiad; wooden fuze plugs.
36. 8-inch spherical case; Bormann fuze.
37. 8-inch canister.
38. 8-inch grape; rings.
39. 10-inch shot; wooden model.
40. 10-inch shell; columbiad, wooden fuze plug.
41. 10-inch grape; rings.
42. 15-inch shot; wooden model.
43. (2) 15-inch shot? Fired at target during experiment at Fort Delaware.
44. 20-inch shot, wooden model.
(5) 20-inch shot.
8-inch carcass (filled with incendiary composition for igniting wooden buildings).

Experimental.

10-pounder cylinder shell; no sabot.
30-pounder spherical shot; coated with lead.
30-pounder spherical glass shot.
30-pounder elongated glass shot.
20-inch spherical shot; stone; from Constantinople.
10-inch shell (Stevens').
Atkins' volcanic.
Atkins' volcanic; polyhedron.
10-inch checkered shot in coppered hemisphere, for use against armor-plating.
10-inch bolt for smooth-bore guns.
1 star-shot (for use against the rigging of ships).
1 chain-shot (for use against the rigging of ships).
Fairbanks' method of making shell, illustrated by sectional specimen.

No. 21. Smooth-bore projectiles, elongated.

For the purpose of obtaining the rifled motion for oblong projectiles fired from smooth-bore guns, attempts have been made to so shape the projectile by providing it with spiral surfaces of various kinds that either the action of the powder in the bore, or the resistance of the air during its flight, or both combined, shall cause a rotation about the longer axis. Many of these projectiles would be influenced, when fired, by the action of the gas and air in opposite directions. The cause of rotation which their construction suggests to have been most decided is here alone recorded.

11-inch, hollow cylinder, rotary motion, caused by action of air on interior.
6.5-shot, hollow cylinder, rotary motion, caused by action of air on exterior.
6.5 (long) hollow cylinder, rotary motion, caused by action of air on exterior.
5-inch shot, hollow cylinder, rotary motion, caused by action of gas on exterior.
4.5-inch shot, hollow cylinder, rotary motion, caused by action of air on exterior.
4.5-inch shot, hollow cylinder, rotary motion, caused by action of air on exterior.
3.5 inch shot, hollow cylinder, rotary motion, caused by action of gas on exterior.
4-inch shot, hollow cylinder, rotary motion, caused by action of air on exterior.
4-inch shot, hollow cylinder, rotary motion, caused by action of gas on exterior.
32-pounder Stevens', hollow cylinder, rotary motion, caused by action of gas on exterior.
24-pounder Stevens', hollow cylinder, rotary motion, caused by action of gas on exterior.
3-inch shot, hollow cylinder, rotary motion, caused by action of gas on exterior.
4-inch shell, hollow; stability maintained by action of air on flanges.
3½-inch percussion shell, with hammer on exterior; stability maintained by action of air on flanges.
Gibbs shot; flanges expanded by springs.

No. 22. Grenades.

Grenades are used against a storming party during the defense of a work. The specimens shown are thrown by hand and either exploded by percussion or by a friction-tube and lanyard after striking, or while in motion. They are:

1-pounder, 3-pounder, and 5-pounder, Ketchum's hand-grenade, fired by percussion.

2-pounder W. W. Hanes hand-grenade (Orsini bomb); within the outer shell is enclosed a smaller, containing the bursting charge, which on impact is exploded by one of a number of percussion caps attached to cones striking against the walls of the outer shell.

5-pounder Adams hand-grenade, fired by lanyard and friction-tube.

2-pounder bridge torpedo.

No. 23. Rockets.

Rockets are used in the military service both as signals and as projectiles. In this latter case they carry at their head either a solid shot, shell, or case-shot. Rotation is caused by the escape of gas through small holes oblique to the axis of the rocket and situated either at the base or at the rear of the head. Under an angle of 47° the range of the largest Signal Service rocket is about 2,200 yards. The specimens exhibited were:

2.25-inch, rotation produced by escape of gas through three holes in base.

2.5-inch, rotation produced by escape of gas through five holes in base.

3-inch (long), rotation produced by escape of gas through three holes at head.

No. 24. Rifle projectiles.

Rifle projectiles are classified herein, according to the manner in which the rifle motion is imparted to them, into the following general groups, viz:

I. *By means of flanges or by giving a peculiar form to the projectile*, e. g., *Armstrong, Whitworth, Rodman.*—The projectiles of this class are generally employed for muzzle-loading guns. They are strong and certain of rotation. They are, however, likely to strain the gun, and require such careful fitting as sometimes to be difficult to load. They may be used either for breech-loaders or muzzle-loaders, though their advantages are more conspicuous when used in muzzle-loaders.

II. *By expansion.*—Expanding projectiles generally have at their base a cup, band, or other arrangement of soft metal, which is expanded by the action of the charge into the grooves of the gun. They can be made to fit loosely in loading, and even though of different patterns may be used in the same gun, *e. g.*, Dyer, Hotchkiss.

III. *By compression.*—Projectiles of this class are generally used in breech-loading cannon. They are generally covered in whole or in part with soft metal, which is generally applied in bands or rings. The bore being smaller than the projectile, a portion of the soft-metal covering is forced into the grooves, thus compelling the projectile to follow the direction of the rifling, *e. g.*, head coated Parker.

I.—By Form.

1. *Whitworth.*—The cross-section is a hexagonal, with the corners slightly rounded. The projectile is first formed so that its cross-section is a circle, and tapering towards the ends; the "flats" are then planed off to match the bore. 3-inch shot; 5.2-inch shot; 5.2 inch shot, long; 7-inch shot.

2. *Armstrong.*—A series of soft metal studs in the sides of the projectile engage with the grooves in the rifling and cause the shot to turn.

3. *Field projectile; 3-inch segment shell.*—A thin cast-iron shell, contains 42 segmental pieces of cast-iron built up so as to form a cylindrical cavity in the center for the bursting charge. It is coated with lead, which is forced into the grooves of the rifling when the piece is fired. (*Vide* Benton, 556.)

4. *8-inch "Blind" shell.*—It is made of wrought iron or low steel, with very thick sides. There is no fuze, the explosion resulting from the heat of impact and the crushing in of the thin cap which closes the mouth of the powder-chamber. The sides and end are so thick that the force of the explosion is directed forward against the backing of the armor on the decks.

5. *Woodbridge*, 1857.—Upon the posterior portion of the shot and enveloping its cylindrical part is cast a lead jacket. This is fluted to fit the grooves of the rifling and is also hollowed out in rear so as to give a thin expandible edge. This hollowing leaves a thin edge next the conical base of the projectile. Sample shown. Shot for rifled 6-pounder.

6. *Sawyer.*—This projectile is cast with rectangular ribs or flanges designed to fit the grooves of the rifling in the gun. The bearing edges of these grooves are protected by strips of brass. The projectile has also an expanding ring in its base provided with a median groove. The following example is shown: 5.8-inch shell.

7. *Rodman.*—In this system the shot is forced to take the rifling by means of rectangular grooves cast on its surface and planed to fit. The following samples are shown: 4.5-inch shot; 8-inch shot.

II.—By Expansion.

(Either of a cup or ring, a band, or by the action of an annular wedge.)

1. *Dyer.*—The soft-metal cup attached to the base of the projectile is expanded by the pressure of the powder-gas into the grooves of the rifling. The cap of corrugated iron on the point is intended to catch the flame which escapes over the projectile and to concentrate it on the time-fuze. (*Vide* Benton, page 559.) This is one of the earliest expanding projectiles known. The following samples are shown: 2.5-inch shot; 3-inch shell, plain sabot, fired; 3-inch shell, fluted sabot; 3-inch shell, fuze igniter; 3-inch shell in section, with fuze igniter in section; 4.5-inch shell, short sabot, with igniter; 6.4-inch shell for 32-pounder, rifled; 7-inch shell for 42-pounder, rifled; 8-inch shell in section; 10-inch shot; 12-inch shot (600 pounds), fired; 12-inch shot in section.

2. *Absterdam.*—Provided with an expanding lead-composed section base, and forward bearing ring of the same metal. The object of the bearing-ring for muzzle-loading rifles is to insure an accurate fit without the expenditure of time necessary to the turn of the intermediate portion of the projectile's surface. The specimens shown comprise: 3-inch shell; 3-inch shell, two bearing-rings; 3-inch case-shot in section.

3. *3-inch "rebel."*—With expanding lead cup in base. The head is checkered to promote its easy breakage or to prevent glancing.

4. *4.2-inch chain-shot for rifle-gun.*—No sabot; probably expansive system. The shot is divided longitudinally, exposing a cavity which contains the chain, the ends of which are fastened to the two halves of the shot. A small cavity in each of the two halves of the shot at the forward end receives a cast-iron ball, which is intended to keep the halves from separating in their rotary flight.

5. *Rebel 4.5-inch shell (no sabot).*—Hexagonal undercut tenon for a cast sabot, (Dyer system). Grooves are cast in this shot in front and rear to receive soft-metal bearing-ring, as in the Absterdam. This is possibly an Absterdam shell which, failing to explode, was picked up, resaboted by the rebels and fired back again.

6. *Rebel 7-inch shell.*—Undercut for a cast sabot (Dyer system). Upon the head of the projectile is fastened a small copper tube, designed to direct the flame of the discharge to the time-fuze at its point.

7. *Rebel rifled 12-pounder (4.62-inch).*—A hollow cavity enters the base for about 2 inches, leaving walls about ½ inch thick. The head is probably cast on a wrought-iron ring for expansion.

8. *Wrought-iron projectile, with pyramidal head, marked Brooke, 7 inch-shot.*—This shot is composed of wrought iron, the base being turned out in a cup with very thin edges

to be expanded by the discharge. The head is formed in a sharp triangular pyramid to assist in penetrating ironclads.

9. *Wrought-iron projectile (Brooke) fired against armor plate.*—The action in upsetting or spreading out the head is here very clearly shown. This is one of the great defects in wrought-iron shot. In striking they cause a great part of the *work* to be expended on the shot instead of on the armor. Efforts are consequently making to harden the shot by chilling it in casting.

10. *Rebel 8-inch wrought iron.*—Cupped out in base, leaving thin edges to be expanded into the grooves of the rifling. On the head of the projectile is welded a steel plate to assist in penetrating ironclads.

11. *Parrott.*—A brass ring is cast into a rabbet formed around the base of the projectile. The flame presses against the bottom of the ring and underneath it, so as to expand it into the grooves. The rabbet is recessed to keep the ring from slipping. The incendiary shell contains two compartments, the lower one filled with the incendiary composition, and the upper one holding the bursting charge. (*Vide* Benton, page 558. A variety of this system, the Reed, is sometimes formed by casting the body of the projectile upon a wrought-iron cup in its base. The following examples are shown: 2.9-inch shot; 3-inch shell; 3-inch shell, Reed sabot; 3-inch shell, percussion; 3.67-inch shell (20-pounder); 3.67-inch case-shot, Reed sabot; 4.2-inch shell, Reed sabot; 4.2-inch shot; 4.2-inch shot, in section; 4.2-inch case-shot, in section, balls held by asphaltum; 6.4-inch shell (100-pounder); 6.4-inch shot, flat top (100-pounder); 4-inch shell, in section-fuze in base.

12. *7-inch incendiary shell, in section.*—The forward compartment holds the burning composition. 8-inch shell (200-pounder); 10-inch shot (300-pounder.)

13. *Rebel 3-inch shell.*—With Reed sabot, made of copper.

14. *Rebel 3-inch shot.*—With copper Reed sabot.

15. *Dimmick.*—A brass ring is cast upon the base of the projectile, and is kept from revolving, and also kept open for the action of the gas by a series of ribs radially disposed. The following examples are shown: 3.67-inch shot; 3.67-inch shot, fired; 3.67-inch fragment of base of shell exploded by fuze in base.

16. *Butler.*—Upon a tenon formed on the base of the projectile is either cast or screwed a ring of softer metal containing on its rear edge a narrow annular V-shaped groove. When the gun is fired, the gas pressure causes a double expansion to take place, the outer lip being forced against the wall of the bore, and into the grooves of the rifling, and the inner lip being forced against the side of the tenon, sealing the joint and preventing any detrusive effect of the gas upon the ring. Invented by Capt. J. G. Butler, United States Ordnance Corps. (See Benton on rifle projectiles.) The following specimens are exhibited:

Muzzle-loading.—These have a simple cylindrical ring at the base without other bearing: 3-inch shell, unfired; 3-inch shell, fired; 3-inch shell, in section; 3-inch case-shot, in section; 3-inch 16-pounder for heavy field-gun, unfired; 4.5-inch shell, unfired; 8-inch shot, unfired; 8-inch shot fired (2); 8-inch shot, fired, in section; 9-inch shot, unfired; 12-inch shot, unfired; 12-inch shot, fired.

Breech-loading.—These have a forward bearing-ring and the sabot is slightly flared to the rear: 3.07-inch shell (2), for Moffat gun; 3.07-inch shell (2), for Moffat gun, fired; 3.07-inch shell, for Moffat gun, in section; 12-inch shot (600-pounds) for Thompson gun; 12-inch shot (600-pounds), for Thompson gun, fired.

17. *Rebel 4.2-inch, Brooke.*—Copper cup sabot, with ratchet notched to prevent turning. *Vide* Abbot, plate iii.

18. *Rebel 6-inch, Blakely projectile.*—With ratchet-shaped head—copper cup in rear. Kept from turning by a square tenon on the base of shot. For use against ironclads, the corners of the ratchet catching in the armor in consequence of the rotation of the projectile.

19. *Rebel 4.2-inch (no sabot).*—Expansion system, probably Blakely. Three holes in base, for dowel-pins on the base of the projectile, which enter these cavities and keep

the sabot from turning. The sabot is slightly cupped to the rear. (*Vide* Benton, p. 560.

20. *Stafford sub-caliber.*—Intended to secure a shot traveling at a very high velocity from a gun of large caliber, and still to secure great penetration in consequence of the small area of cross-section of its forward end. The base is provided with a brass cup of expansion. The following example is shown: 7-inch diameter at base; 5-inch diameter in stem.

21. *3-inch shot (unknown).*—In the base of the projectile is set a central spindle projecting to the rear, and upon this spindle is placed a brass cup convex to the rear. When the gun is fired, this cup is flattened and its edges spread out into the grooves.

22. *James.*—The gas from the combustion of the charge passes through the radial opening which extends from the hollow in the base of the projectile, and presses against the exterior envelope or patch. This band, which is composed of paper, canvas, and lead, is thereby pressed into the grooves of the gun (Benton, p. 559). The following specimens are exhibited: 3.8-inch shell for rifled 6-pounder; 3.8-inch canister; 3.8-inch shot; 4.62-inch shell for rifled 12-pounder; 4.62-inch shot; 6.4-inch shot for rifled 32-pounder; 7-inch shell for rifled 42-pounder, in section.

23. *Hotchkiss.*—The lead band which surrounds the middle of the projectile is forced outward by the entrance of the iron cup, forming the base of the projectile. The edge of this cup is beveled so as to assist in forcing out the lead band. The following samples are shown: 2.6-inch canister expanding sabot. The iron balls of the canister are covered with thick canvas or lead to prevent injury to the rifling. 3-inch shell; 3-inch shell, fluted; 3-inch case, fluted; 3-inch shot, fluted; 3.67-inch (rifled 6-pounder) shell, fluted; 3.67-inch canister, contains three pieces of chain 4 feet each; 4.2-inch shell; 4.2-inch canister; 4.5-inch shell, fluted; 4.5-inch case; 4.5-inch shot; 4.5-inch shot, in section; 4.5-inch case-shot in section, bursting charge in chamber back of balls.

24. *Delana.*—Contains an axial cavity, through which gas passes to expand front bearing-ring, expanding lead up in rear; 3-inch shot very much reduced in diameter between bearing-ring and sabot. The following example is shown: 3-inch shell, lead sabot.

25. *Rebel 24-pounder (unknown).*—The projectile takes its bearing on the grooves by means of a middle band of soft metal (not shown). This band is expanded laterally by the gas which enters the hollow cavity in the base of the projectile, and is diverted laterally into small holes beneath the band. The point of the projectile is fluted to assist it in catching against the armor of ironclad vessels.

26. *Schenkle.*—On the posterior portion of the projectile is formed a long conical surface. This is embraced by a *papier-maché* sabot or ring, which is expanded into the rifling of the bore by being forced onto the cone by the action of the charge. On issuing from the bore the sabot is blown to pieces. (*Vide* Benton, p. 558.) The following specimens are shown: 2.9-inch shell, in section, with sabot; 3-inch shell-tin cap for sabot; 3.67-inch case shot, in section, filled with sulphur; 3.67-inch shot, in section; 4.2-inch shell, for 30-pounder Parrott; 4.2-inch case; 4.5-inch shell; 4.5-inch shell, sections.

27. *Mann (expansive.)*—Upon the posterior surface of a nearly spherical shot is cast a lead band, the outside of which is a cylinder of the same diameter as the shot. Portions of this band are recessed into the shot in the casting. When the gun is fired this band is driven up the inclined surface, back of the shot, and this compressed into the grooves of the rifling. Sample shown: 4.5-inch shot, in section.

28. *Sawyer No. 2.*—The tapered rear of the projectile is covered with a thick coating of lead, covered with brass foil. When fired this lead is driven forward and expanded into the grooves of the rifling. 2.9-inch case-shot; 2.9-inch shell; 2.9-inch shell, in section; 2.9-inch canister; 4.2-inch shot, in section; 4-5-inch shell, in section.

29. *Bockel.*—A thin, brass sleeve projects to the rear, the interior being filled with lead so as to form a cup. This is driven bodily forward on a series of longitudinal flutings on the body of the projectile. The following example is shown: 3-inch shell.

30. *Atwater.*—Three sliding bolts in the base of the projectile are driven forward by the pressure of the gas, and striking against these sliding wedges force the latter outward against a lead-covered band which encircles them. This is forced into the groove of the rifling. 5.82-inch shot for rifled 24-pounders.

31. *Eureka (Arrick or American).*—An annular wedge of soft metal surrounds a conical tenon formed on the butt end of the shot, and when the gun is fired is forced forward up the inclined surface of the tenon, and thence laterally into the grooves of the rifle. This is done by the concave web of soft metal forming the base of the sabot, which, being flattened by the discharge, spreads out against the annular key. 2.9-inch shell; 3-inch shot, in section; 3-inch shell; 3-inch case-shot; 8-inch shot; 8-inch shot, in section; 9-inch shot, fired.

32. *Dana.*—Around the tapered base of the projectile is cast a brass ring, the cross-section of which is tapered to match the base of the shot. When the gun is fired this ring is driven up the inclined base of the projectile and consequently distended into the grooves of the gun. The ring is cast with an interior annular base at right angles to it. This base contains a groove near its inner edge. When the shot is fired the inner lip of this groove is expanded tightly against a tenon projecting from the base of the shot. This seats the joint and prevents any back pressure from gas leaking in between the sabot and the base of the shot. Projections on the inner surface of the sabot lock into corresponding notches in the taper part of the base and keep the shot from slipping. The following specimens are shown: 3-inch shell; 8-inch shot (2); 8-inch shot, fired; 8-inch shot, in section; 9-inch shot; 9-inch shot, fired.

III.—By Compression.

1. *9-inch lead-coated shot.*—A jacket of lead is cast upon the outside of the shot. It is divided by transverse grooves into bands intended to prevent the great resistance which would be due to changing the form of a cylinder of lead running the whole length of the projectile. This is the projectile generally in use for the Krupp breech-loading guns: 9-inch shot, fired (2); 9-inch shot, unfired (2). Same of American manufacture: 9-inch shot, fired; 9-inch shot, unfired.

2. *Mann breech-loading shot.*—The projectile is surrounded by two lead bands, which are compressed into the grooves. The forward ring is extended into a concentric interior cavity which keeps it from slipping. 3-inch shot; 3-inch shot, in section; 8.4-inch shot; 8.4-inch shot, fired.

3. *Parker.*—Two copper rings are screwed on the projectile, one in front and one in rear. The diameter of these rings exceeds slightly that of the bore, so that when fired the bands of the rifling enter the rings sufficiently to guide the shot. The following specimens are shown: 9-inch shot; 9-inch shot, fired.

4. *Hotchkiss new breech-loading.*—A brass band of slightly greater diameter than the bore embraces the middle of the projectile. It is grooved transversely to diminish the resistance which the width of the band would otherwise oppose to the compression or "slugging."

The following specimens are shown: 1.63-inch cartridge complete; 1.63-inch cartridge case; 1.63-inch shell unfired; 1.63-inch shell fired; 1.63-inch shell in section showing fuze; 1.63-inch canister; 3.14-inch segmental shell in section; 3.14-inch case shot in section; 3.14-inch shell unfired; 3.14-inch shell fired; 8-inch segmental shell in section.

5. *Mann.*—Shot wound with rope; action depends on its tight fit. Samples: 4.2-inch shot for 30-pounder Parrott.

6. *4.5-inch lead shot fired from rifled gun.*—Probably fired into snow or water at low velocities, as the shot shows plainly the marks of the rifling.

7. *4.5-inch lead shot fired from rifled gun against iron plate.*—There is a tradition that this shot was once fired through 4 inches of iron armor; resembling the well-known experiment of firing a tallow candle through a pine board.

No. 25. Fuzes.

The collection of specimen fuzes is from the Ordnance Bureau, with additions supplied at Frankford Arsenal, arranged on four boards, as follows:

1. Simple time fuzes in metal, paper, and wood cases.
2. Time-fuze plugs with water-caps, &c.
3. Percussion fuzes, the action of which depends solely upon the impact of the projectiles at some particular point; generally the head of the projectile.
4. Concussion and combination fuzes. Concussion fuzes are those which are ignited by the impact of the projectiles at any point of its surface, and are applicable to spherical projectiles. When united with the time fuze there results the "combination" fuze. A combination may also be made between the percussion and time fuzes.

The following is a list of the varieties included in the collection:

TIME FUZES.

Time fuzes are of three kinds: metallic, paper, and wooden case.

The first consists of a thick metal disk screw plug, having an annular slot in which the fuze composition is pressed and retained by a thin metallic covering.

It is usually cast from type-metal in a brass mold. The fuze is ignited by the gases in the gun, and its time of burning may be shortened by boring into the slot with an awl or gimlet at any desired point opposite a scale of seconds cast on the disk. The whole charge of composition burns from five seconds up to forty, according to its proportions.

Specimens of this class shown differ only in matters of detail; such as the form of the annular slot, the means for inserting and extracting them, &c. They consist of the Austrian, Babbitt, Bormann, Laidley-Bormann, Wright's.

The second consists of a conical paper case, formed by rolling a triangular strip of stout paper on a cylindrical rod or former. The former is withdrawn as soon as the glue used has set, leaving a uniform cylindrical bore, into which the fuze composition is driven, a little at a time, by a drift and mallet. The fuzes are cut to a uniform length of 2 inches, and the column of composition burns from four to forty seconds, according to its proportions. The outside of the case is graduated on its length according to the number of seconds its column of composition is intended to burn; and by cutting or boring through on these marks, its time of burning may be regulated. Generally the gases in the gun are depended on for igniting the fuse. But various special means have been employed to accomplish this; such as a hood to concentrate the gases in the gun, or a priming of powder or quick-match on its exposed end.

The specimens shown are: 4-second, 5-second, 8-second, 10-second, 12-second, 15-second, 20-second, 25-second, 30-second, 35-second, 40-second, 5-second (rebel), 15-second (rebel).

The third consists of a conical plug of hard wood, having a cylindrical bore into which the fuze composition is driven. Each fuze is graduated so that its time of burning may be shortened by sawing off from the smaller end. The specimens shown: 6-pounder, 12-pounder, 8-inch mortar, 10-inch mortar, 13-inch mortar.

TIME-FUZE PLUG.

The service time-fuze plugs are conical, of either metal or wood, to be driven or screwed into the projectile. They are cast or bored with a conical center space for the reception of a paper time fuze. Some of the metal plugs are provided with a water-cap to prevent the fuze being extinguished in ricochet firing over water. One variety shown (Taylor's) has the igniting-hood, to insure ignition of the fuze by concentrating the gases in the gun on the exposed end of the fuze. Another, for hand-grenades (Adams's) is provided with a device for igniting the fuze, after being thrown, by means of a lanyard attached to the looped end of a flattened wire with serrated

edges. This is drawn through a tube inclosing friction powder. Others are provided with holes through which the fuze may be bored to shorten the time of its burning.

Varieties shown.

TIME-FUZE PLUGS.

Wood.—Three-inch; 12 pounder; 8-inch siege; 8-inch sea-coast; 10-inch shell; 4.5-inch shell; 3-inch shell.

Metal.—Hotchkiss; Parrott; Navy, with water-cap; Parrott; Navy, with water-cap; 3-inch, with water-cap; Navy, with water-cap; rebel, sea-coast, with water-cap; Navy, with water-cap; Parrott, with water-cap; Hubbel's, with water-cap; Adams, hand-grenade with igniter; Hotchkiss; Taylor, with igniting hood.

PERCUSSION FUZES.

1. *Absterdam, front, with safety device.*—Metal screw-plug, inclosing plunger held in position by safety device of tin. On impact the plunger is thrown forward and explodes percussion cap on cone, the flame from which penetrates to the bursting charge.

2. *Butler's rear.*—Brass screw plug, terminated by cylindro-spherical fuze, having perforations inclosing flattened wires with serrated edges surrounded with friction powder. The fuze is attached to the plug by these wires. On impact the fuze is detached and the wires pulled through the cavities, igniting the friction powder and bursting charge.

3. *Rebel, front, with safety-pin.*—Brass screw-plug, inclosing plunger held in position by safety-pin. The pin is removed before inserting the fuze. On impact the plunger is thrown forward and explodes the percussion cap on cone, the flame from which ignites the bursting charge.

4. *Curran's, rear, with safety-spring.*—Brass screw-plug inclosing plunger, safety-spring, and tripping lever. On impact the lever releases the plunger, which is driven forward by the spiral spring, exploding percussion cap, the flame from which ignites bursting charge.

5. *Hotchkiss, front, with safety device.*—Brass screw-plug, inclosing plunger held in position by pins in conical plug. On impact the plunger is thrown forward, exploding percussion cap, the flame from which ignites bursting charge.

6. *Hotchkiss, front.*—Same as preceding one in construction and operation.

7. *Hotchkiss, front, capped.*—Same as preceding one in construction and operation, except that the cup is removed and screw-plug reversed before inserting fuze. The quick-match wrapped on screw-plug adds to the volume of flame from percussion cap to insure ignition of bursting charge.

8. *James's, front.*—Plunger and screw cap separate. The plunger and screw cap are inserted, and, on impact, the former moves forward, explodes percussion cap, and ignites the bursting charge.

9. *Janezeck & Simpson, front.*—Brass conical plug, inclosing plunger attached to flattened wire with serrated edges, which is surrounded by friction powder. On impact the plunger moves forward, drawing wire through friction powder, the flame of which ignites bursting charge.

10. *Parrott's, front.*—Same as James's in construction and operation.

11. *Parrott's, front, with safety device.*—Screw plug inclosing plunger with safety device. On impact the studs of safety device are sheared off by the plunger moving forward to explode percussion cap, the flame of which ignites bursting charge.

12. *Parrott's, front, with safety device.*—Same in principle and general features of construction and operation as preceding one.

13. *Patterson's, front* (2 specimens).—Metal screw plug inclosing plunger. On impact plunger moves forward, explodes percussion cap on cone, and ignites bursting charge.

14. *Shenkle's, front, with safety screw* (2 specimens).—Screw plug inclosing plunger held in position by safety screw. The screw is removed before insertion or sheared off by shock of discharge. On impact the plunger moves forward, exploding percussion cap on cone, through which flame passes to the bursting charge.

15. *Rebel, front.*—Screw plug inclosing plunger with cone and percussion cap. On impact the plunger moves forward and explodes cap, igniting bursting charge.

16. *Petman's, front, English.*—Brass screw plug inclosing perforated powder cylinder and sphere of percussion powder. On impact the sphere is crushed and explodes, communicating flame by channel in powder cylinder to bursting charge.

17. *Laidley's, front.*—Brass screw plug and detached screw cap. The plug incloses a tube containing a flattened wire with serrated edges, surrounded by friction powder. The exposed end of the wire is provided with a plunger or weight. On impact the wire is drawn through the tube, igniting friction powder, which fires the bursting charge.

18. *Rebel, front.*—Paper case, metallic head. The head contains percussion powder, which is exploded by impact and ignites bursting charge.

19. *Rebel, front, with safety spring.*—Brass screw plug inclosing plunger. The safety spring is removed before inserting fuze. On impact the plunger moves forward, explodes the percussion cap, and ignites the bursting charge.

COMBINATION FUZES.

1. *Laidley's concussion igniter and time fuze, front.*—Brass screw plug, bored for time fuze. Two cylindrical holes contain friction igniter, which consist of a brass tube closed at one end and filled with friction powder, into which a flattened brass wire, with serrated edges, is inserted. The exposed end of the wire is weighted with lead. The shock of discharge pulls the wire through the friction powder, which ignites the time fuze through a small hole in the side of the tube, near its closed end.

2. *Stevens's concussion and time fuze, front.*—Brass screw plug, with cylindrical bore, inclosing a plunger and pellet of percussion powder. A time fuze, in brass case, is screwed into the open end. The shock of discharge throws the plunger against the pellet, and ignites the time fuze.

3. *Arrick's concussion and time fuze, front.*—Brass screw plug, with attached metal time fuze, inclosing a friction igniter of same construction as Laidley's above described, and which ignites the time fuze in the same manner.

4. *Laidley's concussion igniter and time fuze, front.*—Metal screw plug, inclosing paper time fuze. Beside the fuze a hole is provided for the reception of an igniter, made as above described, and acting in the same manner.

5. *Sawyer's combination fuze, front.*—Brass screw plug, inclosing paper time fuze, opposite which holes are bored to facilitate tapping the fuze. A brass tube, inclosing a lead cylinder, is attached to the head of the plug to serve as an igniter. The shock of discharge throws the lead cylinder on a layer of percussion powder at the bottom of the tube, and, exploding it, ignites the time fuze.

6. *Armstrong's combination fuze, front.*—Brass screw plug, inclosing paper time fuze and sphere of percussion combination. The shock of discharge crushes the sphere, the flame of which ignites the time fuze.

7. *McIntire's combination fuze, front.*—Paper time fuze, with column of composition bored to receive a pipe clay tube, filled with rifle powder and closed at upper end. The time fuze is ignited by the gases in the gun. On impact that part of the clay tube left unsupported by the burning away of the fuze is broken, and the rifle powder it contains communicates flame to the bursting charge.

8. *Sawyer's concussion igniter and time fuze, front.*—Brass screw plug inclosing paper case time fuze. At the top of the plug is a tube inclosing a brass cylinder, and in the bottom of tube is a layer of percussion composition. The shock of discharge throws the cylinder against the percussion powder, which explodes and ignites the time fuze.

9. *Shenkle's combination fuze, front.*—Metal screw plug inclosing column of time-fuze

composition in metal case. The plug and case have spiral rows of holes bored through them, by which the time of burning is regulated. Ignition of the fuze is secured by a metal cylinder with serrated edge, which, by the shock of discharge, is thrown against a layer of percussion powder at the bottom of the cavity in which the cylinder is fixed.

10. *Rebel concussion igniter and time fuze, front.*—Brass screw plug with attached wooden head. The plug incloses a paper time fuze, and the head is bored to receive a friction igniter of the same construction as Laidley's. By the shock of discharge the friction igniter fires the time fuze.

11. *Hotchkiss combination fuze, front.*—Brass screw plug; paper time fuze, with cap, inclosing layer of percussion powder and plunger. The shock of discharge throws the plunger against the percussion powder, and thereby ignites the time fuze.

12. *Woodbridge's combination fuze, rear.*—Brass screw plug, in two parts; held together by a brass pin, inclosing a paper time fuze. A cap with circular tip fits a recess in head of plug containing quick match. The gases in the gun bend the lip and fire the quick match, which ignites the fuze. On impact the forward part of the plug is pulled off and carries with it the burning time fuze into the bursting charge.

13. *Drake's combination fuze, front.*—Brass screw plug, inclosing paper time fuze and a plunger with percussion caps at each end. At the shock of discharge the front plunger ignites the time fuze, and on impact of the projectile the rear plunger ignites the bursting charge.

14. *Treadwell's Splingard combination fuze, front.*—Paper time fuze with central bore, lined with metal casing and inclosing a pipe clay cylinder filled with rifle powder. The gases in the gun ignite the fuze, and, on impact, that part of the clay cylinder left unsupported by the burning away of the fuze composition and melting of the metal casing breaks, and its enclosed rifle powder inflames the bursting charge.

15. *Rebel combination fuze, front.*—Brass screw plug, inclosing time fuze with conical metal plug in its center, and a plunger and percussion cap. The shock of discharge ignites the time fuze, which burns during the flight of the projectile. On impact the plug is thrown out of the fuze composition, to allow flame to pass to the bursting charge.

16. *Arrick's combination fuze, front.*—Similar to Arrick's fuze before described in its construction and action.

17. *Clapp's combination fuze, rear or front.*—Brass screw plug, with two longitudinal chambers; one incloses a paper time fuze; the other a plunger fitted with a percussion cap at each end. The shock of discharge on the plunger explodes one of the percussion caps, and ignites the fuze, and the impact of projectile explodes the other cap, which ignites the bursting charge.

18. *Butler's concussion fuze, rear.*—Brass screw plug with cylindrical chamber, inclosing a plunger held in position by safety pin, and a metallic center fire cartridge head inclosing powder. The shock of the discharge releases the plunger by shearing off the safety pin, and the impact causes it to explode the cartridge and ignites the bursting charge.

19. *Belgian concussion fuze, front.*—Metallic time fuze in head of metal screw plug inclosing plunger, and percussion cap, which ignites bursting charge on impact of projectile.

20. *Beebe's concussion fuze, rear.*—Metal screw plug, with slot at end to receive a thin metal cross-plate by which the fuze is attached. It consists of a cylinder, with spherical end to give preponderance of weight. The cylindrical portion has a large central bore, and two smaller side bores connected with the large one by slits. A plunger, resting on a spiral spring, has wings with serrated edges that enter the small side bores through the slits. The side bores are filled with friction powder. The shock of discharge breaks the cross-plate and allows the fuze to immerse itself in the bursting charge. On impact the fuze is thrown with its heavy end forward against the walls of the projectile. This is done with force sufficient to cause the plunger to

compress the spring and ignite the friction powder in the side bores, which inflames the bursting charge.

21. *Tice's concussion and percussion fuzes.*—No. I and II (before and after firing). The metal case incloses a pipe containing fulminate held by safety devices within chamber and surrounded by small shot. When fired, the safety studs are bent and the pipe allowed to move forward. By this motion the fulminate, inclosed in a glass tube, is left exposed in the chamber with the shot, and exploded on impact by contact with them. The glass tube containing fulminate and the shot are not shown in specimens The pipe is shown in specimen marked VI.

No. III is a concussion fuze. The short column of composition is ignited at the discharge, and, burning out, allows the plunger to move forward on impact. This prevents the escape, in front, of the gas developed by the burning of the longer column, which is forced to the rear and ignites the bursting charge.

Nos. IV and V. (Before and after firing.) Percussion fuze, consisting of plunger with four caps on cones held in position before firing by a lead ring in a metal case. When fired the ring is torn off and the plunger freed; and on impact one of the caps strikes against the wall of the case and ignites the bursting charge.

No. 26. Priming horn.

Formerly used in priming cannon. It contained fine powder with which to fill the vent. This was ignited by a slow match or port-fire.

No. 27. Port-fire.

Port-fire consists of a mixture of niter, sulphur and mealed powder contained in a paper case used for setting fire to primers, quick match, &c. Formerly the port-fire was ignited at the slow match, which was held in the linstock, the latter being planted in the ground. As the port-fire only burns about ten minutes, as soon as possible after using it the burning part was trimmed off with the port-fire cutter.

Port-fire holder.—Used formerly to hold port-fire. The port-fire was lighted at a slow match held in the linstock planted in the ground near by.

Port-fire cutter.—Used in trimming port-fire after each discharge. (See cleft linstock.)

Cleft linstock.—Used formerly to hold the slow match of twisted cotton rope used to light the port-fire by which the piece was fired. The linstock was stuck in the ground near the gun, with its match burning, and the port-fire lighted for each shot. After each fire the burning part was trimmed off with the port-fire cutter also shown. The objections to the slow match were the trouble of lighting it, its liability to become extinguished, and the information conveyed by its burning tip to the enemy in night work. It was superseded by the cannon lock, which in turn gave way to the friction primer, *q. v.*

Linstock, solid.—Differs from cleft linstock by having a hole through its head for the insertion of the slow match. (See cleft linstock).

No. 28. Priming tubes.

Made of lead composition. The cap at the head is filled with mealed powder protected by varnished paper. When used, the tube was inserted in the vent and set fire to by the port-fire, which see. When invented this was considered a great improvement over the method of priming from the horn which was then in vogue.

No. 29. Hidden's patent cannon lock, No. 1, mounted on section of gun.

The lock is set forward of the vent; the lanyard running directly to the rear. The hammer is kept off the percussion primer by the flat spring beneath the stem of the hammer. This spring is overcome by a jerk given to the lanyard, after which the spring throws up the hammer again into the firing position. The curved spring on the tail of the hammer rides stiffly over a curved surface on the hinge and catches the

hammer after it is thrown back by the blast from the vent. A side spring throws in an arm in front of the hammer and blocks it, when desired, to prevent an accidental discharge of a loaded piece.

No. 30. Hidden's cannon lock, No. 2.

The hub of the hammer is grooved circumferentially for the lanyard, and is inclosed by a cap, which keeps the lanyard from slipping off. The lanyard passes through a guide directly to the rear, the hammer being in front of the vent.

No. 31. Hidden's cannon lock, No. 3, with vent pad, mounted on section of gun. Left hand.

The joint hole in the hammer is considerably elongated, so that after the hammer has fallen and fired the primer, the pull on the lanyard draws it bodily away from the effect of the blast through the vent.

The vent pad is swung upon the hammer frame, and turned over the vent while sponging. It is kept down upon the vent by a flat spring, forming its connection with the pivot.

No. 32. Hidden's cannon lock, No. 3, for vent pad (without pad). Right hand.

No. 33. Perkins's cannon lock, 1837 (2 specimens; 1 very heavy of iron).

The hammer plays in a plane at right angles to the axis of the gun. As it falls, a spur on its lower part moves back a slide in the frame, the forward part of which forms the vent cover. When the hammer is raised, the weight of the slide carries it forward over the vent, over which it may also be pushed by hand. The eye in the frame serves to lead the lanyard to the rear.

No. 34. Friction primers in various stages of manufacture.

Friction primers used for firing cannon consist of two brass tubes soldered together at right angles. The upper tube contains powder composed of chlorate of potassa and sulphuret of antimony, which is ignited by heat caused by the friction developed in pulling through it a jagged wire. The longer tube, which is inserted in the vent, contains grain powder and transfers the flame to the cartridge.

No. 35. Electric primer.

The transversal head contains a pinch of gun cotton traversed by a fine platinum wire. When conducting the electric current this wire becomes red-hot, igniting the gun cotton, which sets fire to the rifle-powder contained in the long tube. Largely used in experimental firing as well as in the simultaneous discharge of several pieces.

C.—Small Arms.

The muskets and rifles described herein are classified both in the catalogue and in the racks according to the system proposed in connection with the Report of the Small-Arm Board, Ordnance Memoranda XV, or Report of Chief of Ordnance, 1873.

To summarize: First comes the *muzzle-loaders*, chronologically arranged, as far as possible in regard to development showing the match-lock, the wheel-lock, the *flint lock*, and the percussion lock, of which many curious varieties will be seen. Then come the *breech-loaders*, the first of which in the sequence of development are those with movable

chambers. Mechanically, too, the movable chamber is an intermediate step between the muzzle-loader and the true breech-loader, being essentially a very short muzzle-loading barrel fired through another barrel open at both ends. Revolvers form about the only example of this class of arms which have not become obsolete. Indeed, confining our attention to the cylinder alone as a series of short *barrels*, and taking the case of modern revolvers using a metallic cartridge, they become true breech-loaders with fixed chambers, opened and closed by the revolution of the cylinder.

The breech-loaders with fixed chambers, the true breech-loaders, are classified according to the motion of the principal part by which the breech is opened and closed. This may be either the barrel or a special breech block. The relative motions of these parts, whether sliding or revolving—if revolving, according to the direction and position of the axis on which they turn—are the basis of the classification of these arms.

In each of these classes of breech-loaders the arms are arranged with reference to their chronological order. This order is broken, however, whenever the arms are nearly related, either mechanically or functionally.

MUZZLE-LOADING MUSKETS AND RIFLES.

Match and flint locks.

No. 1. Match-lock of the fourteenth century; caliber, .70.

Pulling the trigger raised the sear which by means of an intermediate lever brought the lighted end of the match into contact with the pan. This gun is probably one of the earliest portable fire-arms made. *One* objection to match-locks was that the blast from the vent or *touch*-hole (note the etymology) would blow out the match. This gun is light enough to fire from the shoulder, consequently no crutch was employed.

No. 2. Japanese match-lock; smooth bore; caliber, 1.1 (now obselete).

The match, probably of twisted cotton rope, is held in the cleft of the brass match-holder and confined by a transverse key. The loose end of the match passes through a transverse hole in the stock. The holder is cocked and caught when up by a sear connected with the trigger in the butt of the piece. When the trigger is pulled, the match falls forward a short distance into the pan. The brass fender next the vent is probably intended as a protection against the flash. The object of the intermediate brass sight is not apparent.

It is possible that the large iron bases were added afterwards. They are slit with the evident intention of using a movable sight leaf. The finish of this gun is very good.

The weight of the gun and the form of the butt-stock render it probable that this gun was used as a wall piece, the barrel resting on the wall and the butt being held at the hip.

Loaned by General W. B. Franklin, vice-president and general agent Colt's Patent Fire Arms Company, Hartford, Conn.

No. 3. Chinese match-lock; caliber, .53.

The match-holder is curved and pivoted at its middle point, so that the extension of its tail beneath the stock forms the trigger. When this trigger is grasped by the

hand the match descends into the pan and fires the piece. A flap forming a sort of pouch is attached to the side of the stock and serves to carry an extra supply of cartridge. The mountings of the gun, brass bands, cotton-slings, iron ramrod and sights are of the most primitive character. The shape of the butt-stock would indicate that it is meant to be fired from the hip.

Loaned by General W. B. Franklin, vice-president and general agent Colt's Fire Arms Company, Hartford, Conn.

No. 4. Wheel-lock; caliber .70; rifle. Date unknown.

A ribbon-spring in the lock was wound up by a separate key, and the face of the flint then brought down upon the roughened surface of the wheel. By touching the trigger the wheel was released, and by its rapid rotation against the flint the sparks were produced which fired the charge. This gun was probably used as a wall piece or with a portable crutch in field firing. A slide covers the pan to keep the priming from falling out. A set lock is probably indicated. It is remarkable for the fineness and force of its engraving, and for the general beauty of its form and finish. The barrel bears the name of the maker, Gottfried Helming, U. U. ig., with his medallion and initials inlaid. The wheel-lock was invented at Nuremberg, in 1517. The rifle was invented about 1500. A similar gun is represented in Johnson's Encyclopedia.

Wheel-lock (detached) in working order (see description of wheel-lock pistol). By pressing a knob outside the lock-plate, the pan-cover slides back and protects the priming from wet or loss. The key is permanently attached to the arbor winding up the spring.

Loaned by General W. B. Franklin, vice-president and general agent of Colt's Patent Fire Arms Company, Hartford, Conn.

No. 5. Ancient flint-lock (detached).

The fall of the cock by means of a sliding rod inside pushes forward a slide cover for the pan just before the flint strikes the steel. The sear consists of a double trigger working horizontally. Its nose passes through the lock-plate and engages with a notch in the back of the hammer outside.

Loaned by General W. B. Franklin, vice-president and general manager of Colt's Patent Fire Arms Company, Hartford, Conn.

No. 6. French flint-lock musket; model, "1763"; caliber .71.

Marked U. S. on barrel and lock-plate. Barrel fastened with three iron bands to stock. Mountings of iron. Swivel loops for gun-sling, with bend for lug.

No. 7. British flint-lock musket; caliber .81. Probably dating from the time of Queen Anne.

Bears on lock-plate crown and letters A. R. with U. S., on barrel crown and G. R. The gun resembles the Tower musket in this collection, but is not so substantially made. This gun and the French musket probably served mainly for the armament of the Revolutionary armies. Barrel keyed to stock. Brass mountings.

No. 8. Wall-piece, rifled, flint-lock; caliber 1.25. Rappahannock forge.

The first arms made by the United States are supposed to have been fabricated at the Rappahannock forge, probably about 1785.

No. 9. Muzzle-loading flint-lock blunderbuss; caliber 1.40.

No marks. Brass barrel. With cylindrical chamber.

No. 10. Flint-lock blunderbuss.

Bell muzzle; diameter of muzzle, 2 inches. Barrel keyed to stock.

No. 11. English Tower flint-lock musket; caliber 75.

Almost new; bears on barrel "20 Regiment"; on lock plate, "Tower" and "G. R." with crown. Barrel keyed to stock; brass mountings; good finish.

This is the arm with which almost all the fighting of the Revolution was done.

No. 12. Cadet flint-lock musket; caliber .54. Made at Springfield Armory, 1808.

Barrel keyed to stock; brass mountings; fair finish; butt begins to widen; no clasp to bayonet. A very light and pretty gun.

No. 13. Flint-lock blunderbuss; caliber about 7.25; splay muzzle. Harper's Ferry, 1811.

Used in firing slugs, &c. The muzzle is bell-shaped and extended laterally to 3¼ by 2¼ inches vertically. Brass butt-plate; barrel fastened by pins; barrel keyed to stock.

No. 14. United States Harper's Ferry flint-lock rifle; caliber .53, 1814.

Barrel keyed to stock with iron rib and pipes; brass mountings, rear sight (fixed), patch-box, seven grooves, semicircular channels, twist lock, &c. Much lighter than in previous arms.

No. 15. Flint-lock musket; caliber, .70. Made at Springfield Armory, 1815.

Remarkable for the beautiful wood of which the stock is formed, taking in certain lights a greenish cast. Bayonet without clasp; barrel secured with three iron bands.

No. 16. Flint-lock smooth-bore musket; caliber, .70. Springfield Armory, 1818. Magazine primer.

An arm projecting forward horizontally from the eye of the hammer, gives a partial revolution at each movement to a fluted cylinder forming the bottom of the pan. As the hammer is drawn back to cock it this cylinder revolves to the front, and takes its charge of priming powder from the brass magazine above it. As the hammer falls the cylinder is brought back opposite to the vent in time to receive the sparks from the steel. An interesting, though probably not an efficient, prototype of the Maynard primer. Bayonet without clasp.

No. 17. Flint-lock muzzle-loading rifle; caliber, .48. Made by Leman, Lancaster, Pa.

Barrel octagonal, 3 feet 6 inches long; rifled with seven square grooves about .03 inch wide by .03 inch deep. Patch box in butt contains implements and powder charger. Stock of a favorite pattern among backwoodsmen, made of curled maple, dyed.

No. 18. United States flint-lock, wall-piece, model 1820; caliber, 1.40; enlarged at muzzle to 2.05.

Barrel and mountings of gun-metal; front action lock with mainspring outside; swivel under tip stock. Designed to fire shot or small balls against an attacking column. Ramrod spring to prevent ramrod from being thrown out forward by recoil. Never much used.

No. 19. Wall-piece, flint-lock, smooth-bore, bronze barrel; caliber, 1.5.

Lock made at Springfield Armory.

No. 20. Wall-piece, flint-lock, smooth bore; caliber, 1.3. Pittsburgh.

No. 21. Smooth-bore flint-lock musket; caliber, .70. Springfield Armory, 1821.

This gun was made in the second quarter of 1821 for comparison with other guns of the same date made at Harper's Ferry. This was done every three months to insure parallelism of workmanship between the two places. For the first time the barrel and many of the mountings are browned. The bayonet being also browned half length. The browning is intended to protect the arm from rust and also to conceal troop from the attention excited by the shining of their bayonets when polished. All United States arms are now browned, though with a very much better browning than that here shown.

No. 22. Cadet flint-lock musket; caliber, .59. Springfield Armory, 1830.

All iron parts are browned. Bayonet without clasp.

No. 23. Flint-lock muzzle-loading musket; caliber, .67. Springfield Armory, 1843.

The last of the flint-locks, a few of these being made after the percussion model 1842 was adopted.

No. 24. Flint-lock musketoon; caliber, .75, enlarged at muzzle to 1.05.

Used by cavalry or dragoons. Provided with swivel bar and ring. Marked U. S. on barrel. Brass mountings; barrel keyed to stock.

No. 25. French flint-lock musketoon; caliber, .69. Made at Mudzig.

The ramrod, although it is of full length, is arranged to pass obliquely to the left between the side plate and the guard, and then to descend into the small of the stock. This diminishes its projection and consequent liability to accident.

No. 26. Ellis (pat.?) repeating flint-lock rifle; caliber, .54; seven grooves.

The gun was loaded by ramming down the four charges, one on top of the other. The lock was then pushed opposite to the foremost vent and held there by the little apron closing the vent nearest to the rear. It was supposed that the flame was kept from reaching the next charge by tight ramming of the intervening ball. The apron having then been lifted, the lock was slid back to the next hole, and the process continued. A small reservoir for the priming powder is seen attached to the pan. By raising this up before each shot, and rapping the piece, the pan was filled. This rendered the piece self-contained, as the powder horn or cartridge box were not required for its service. All mountings browned; rifling shallow; grooves about .01 inch deep and .03 inch wide.

No. 27. Albanian smooth-bore flint-lock musket; caliber, .73. From Missolonghi.

Resembles very much in length, style of ornamentation, &c., the Albanian musket above, but is banded and inlaid with silver. The hammer has a special dog outside the lock plate for holding it off the steel. The hand of the firer is protected from abrasion by a leather flap. The piece has no trigger-guard. The butt plate is of brass and uncomfortably narrow.

No. 28. Arab smooth-bore flint-lock musket; caliber, .65.

Barrel 4 feet 10 inches long; total length, 6 feet 1 inch. Some parts of the lock are wanting. It is probable that the tumbler was outside the lock-plate. The locking of the hammer draws the pan-cover over the pan, and protects the priming from wet,

&c. The fall of the hammer pushes this cover forward and allows the sparks from the steel to fall into the priming and ignite the charge. This gun has no less than six bands of sheet brass confining the barrel to the stock. Its butt plate of bone is highly decorated on the sole. The length of guns of this class is probably due to the imperfect gunpowder manufacture of the period. This being used as slow-burning mealed powder, the long barrel was necessary to allow complete combustion. Even now it is reported that the Arab will follow a moving object for some time with the barrel after pulling the trigger, in order to allow for certainty of the piece hanging fire.

MUZZLE-LOADING MUSKETS AND RIFLES.

Percussion locks.

No. 1. Early percussion lock.

The traces of the recent flint and steel are apparent in this lock. (See magazine primer flint-lock and Collier's revolving flint-lock.)

The percussion powder in pellets is contained in a hollow magazine pivoted to the lock-plate at the striking point of the hammer. This is connected with the hammer by a link which causes the hammer and magazine to follow each other's movements. As the hammer falls the magazine also falls forward, exposing a pellet of fulminate lying in a cavity on the upper side of the arbor. This arbor is hollow and communicates the fire to the inside of the barrel. Loaned by General W. B. Franklin, vice-president and general agent of the Colt Patent Fire-Arms Company, Hartford, Conn.

No. 2. Percussion smooth-bore musket; caliber, .69. Springfield Armory, 1842.

The first model of the United States percussion musket, first used in the service in the Mexican war. The supply being insufficient, however, flint-locks were generally employed. Bayonet has clasp.

No. 3. Wall-piece percussion, rifled, model 1846; caliber, .80. Made at the Springfield Armory.

The last model adopted in the United States, none of the pattern, however, being made.

No. 4. Heavy muzzle-loading rifle mounted on a tripod.

Designed for use by sharpshooters firing from a considerable distance to annoy the defenders of a besieged work.

No. 5. Lindsay repeating rifled musket; caliber, .58; patented 1850. (Experimental.)

The (single) barrel contained at its butt two cartridges rammed, the ball of the lower cartridge being forcibly expanded into the grooves, so that the fire would not lead back from the first cartridge when ignited. Two hammers placed side by side at the butt of the barrel exploded the charges successively, the channel corresponding to the right-hand hammer leading directly to the forward charge. The barrels have but one trigger, which is set for the second charge only after the first charge has been fired. There is thus no danger of accidentally firing the rearmost charge first (See Ellis repeating flint-lock musket.)

No. 6. Rifled musket; caliber, .58. Springfield, 1851.

Provided with rear sight with adjustable leaf. English Enfield pattern.

No. 7. Smooth-bore musketoon; caliber, .69. Springfield Armory, 1854.

No swivel bar; brass mountings; ramrod swivels.

No. 8. Rifled musketoon; caliber, .69. Springfield Armory.

Brass mountings; ramrod on swivel to prevent loss in loading on horseback; swivel-bar very long, reaching from lower band to rear side screw.

No. 9. Springfield rifled musket; caliber, .58. Model, 1855.

Designed by Col. (then Lieut.) J. G. Benton, United States Ordnance. (See book, Small-Arms, 1856.) This particular weapon is a "model" gun, having been made by hand as a standard for gauges, and to make tools by for extended manufacture. The accuracy of its parts and the time spent in its manufacture made it cost about $600 or $700.

No. 10. Springfield rifled musket; caliber, .58. Model of 1855.

One of the regular manufacture.

No. 11. Smooth-bore musket with Maynard primer. 1855.

One of the first guns made with this primer. Invented by Dr. E. Maynard, Washington, D. C., and adopted by Mr. Jefferson Davis, Secretary of War. The cocking of the hammer throws up a pawl connected with the forward part of the eye of the hammer. This pawl pushes up, one section at a time, the tape-like primer lying coiled in a circular recess in the lock-plate. When the hammer falls, the knife-edge on its face cuts off the protruding section from the rest of the tape, and the face of the hammer carries it forward to the cone, where it is exploded. The primer consists of two narrow strips of varnished paper containing between them at regular intervals the pellets of fulminate. The primer was intended to dispense with the use of the percussion cap and to save the time lost in placing it by hand. In practice it was found open to many objections, which caused its abandonment. (See the flint-lock magazine primer, *ante*.)

No. 12. Harper's Ferry rifle; caliber, .50. 1860.

The favorite rifle of Secretary Floyd; used by him extensively in target practice. The wood of the stock is remarkably fine.

No. 13. Enfield rifled musket, 1862; caliber, 5.77. Cleaned and repaired.

The English arm of this name was largely used in preparing the model of the United States rifled musket, model 1855. Many of these arms were used during the war of the rebellion. The model of the United States rear-sight was derived from the English pattern. This particular arm was turned in from the field after the war, and cleaned and repaired for further issue or for sale.

No. 14. Rebel rifle; caliber, .50.

Seven shallow, narrow grooves; no marks; fixed rear-sight, brass mountings; poor workmanship. Butt plate of sheet-iron with square end to tang reaching across butt to save labor in fitting it. Bayonet possibly captured. Stamped "Collins Co., Hartford, 1862."

No. 15. Rebel musketoon; caliber, .58. Made at Richmond, Va., 1862.

The peculiar shape of the lock-plate is probably due to its having been forged in dies intended for the Maynard primer lock—taken from Harper's Ferry or Fayetteville, N. C., armories. The unnecessary thickness of the lock-plate also point to the same conclusion.

No. 16. Rebel musket; caliber, .70. State Works, Greenville, S. C., 1863.

The principal feature of interest connected with this gun is the lock, which is known as Morse's, and is of the back-action, center-lock variety. It forms an exceedingly simple and ingenious lock, well protected from the weather, and capable of manufacture by unskilled labor. The lock-frame consists of a strap of one-eighth inch iron one-half inch wide, and about 12 inches long, bent double, with its branches about three-eighths inch apart. This contains the pivotted main-spring, trigger-spring, and trigger. Its forward end, where it is bent, is widened and pierced for the bearings of the tumbler-shaft, which supports the tumbler between the two sides of the frame. The hammer on the outside end of the tumbler-shaft completes the list of the essential components. There is also a main-spring swivel, two tumbler (?) screws, and two brass bearing plates at each end of the tumbler-shaft with their screws. The whole lock is bedded above the trigger-guard in the small of the stock.

No. 17. Smooth-bore wall piece; caliber, .95. Of rebel manufacture.

The lock of a fowling-piece is adapted to a stock, &c., evidently "home-made." The bands are of sheet brass, lapped and soldered; guard and butt-plate of brass.

No. 18. Rebel rifled musket; caliber, .52.

Seven shallow round grooves with curious lock and sword bayonet. The hammer and tumbler are in one piece, without half-cock notch, the hammer being inside the lock-plate. Fixed rear sight. The workmanship of the bayonet is very good. The blade is particularly well formed.

No. 19. Rebel rifled musketoon; caliber, .68.

Three wide very shallow grooves made by Cook Bros., Athens, Ga. No. 4626. Confederate flag on lock-plate; brass mountings as usual in rebel manufacture.

No. 20. Light rebel rifle; caliber, .50.

Seven square shallow grooves. The workmanship is the point most remarkable. Considering the difficulties labored under, it is more than good.

No. 21. Smooth-bore musket; caliber, .54. Unknown (Morse's?).

Hammer directly in rear of the barrel, forming the center-lock adopted for many modern breech-loading arms.

No. 22. Springfield rifle. Model 1864.

This is the arm made in greatest numbers during the war of the rebellion. It differs mainly from the model 1855 in the change in the rear-sight, and the omission of the Maynard primer. The necessity for the immediate production of guns did not allow time for changing the lock-plate tools so as to reduce the thickness of the lock-plate from the thickness required by the Maynard primer. Some of the minor details of the mountings are also altered.

No. 23. French smooth-bore double-barreled musket for dragoons, gens-d'armes; caliber, .69. Manufacture Nationelle de St. Étienne.

Has a knife-bayonet lying in plane of barrels which is edged for only half its length; is fastened by a pivoted lever at its side to a stud on the side of the barrel.

No. 24. Double-barreled rifle; caliber, .51. Made by M. Brunner in Munich.

Barrels superposed; ramrod on side; seven grooves; hammers side by side; foliated carving under guard-strap; brass patch-box.

No. 25. Telescopic sporting or target muzzle-loading rifle; caliber, .45. Made by James. Exhibited in laboratory. (See Benton, p. 319.)

This arm contains many refinements which, though ingenious and effective, are incompatible with the strength and safety of a military arm. This rifle was fired with a bullet of 217 grains, burning 100 grains of powder. Initial velocity, 1,900 feet.

BREECH-LOADING MUSKETS AND RIFLES.

Movable chambers.

No. 1. Hall's breech-loading flint-lock musket; caliber, .69; model 1827 (proximately).

Ten thousand of these arms were made at about this time and issued to the troops, being the first breech-loading arms used in quantities by any nation. (See description of lay figure representing the rifleman of 1818; see, also, Norton's American Breech-loading Small-Arms.)

No. 2. Hall's percussion breach-loading rifle; caliber, .54. Harper's Ferry, 1832.

Nine very shallow round grooves; the same as the old Hall rifle, 1818, with the exception of the change of lock. The gun is opened by pulling back the catch. When open the chamber is loaded by dropping into it the cartridge. The chamber is so short that this is easily done. The block is then closed. No provision for a gas-check was made in these guns. A joint, loose for one thickness of writing paper but binding on *two*, being considered tight enough to prevent the escape of gas, and yet loose enough for free manipulation.

No. 3. Hall's breech-loading smooth-bore percussion carbine; caliber, .64. J. Hall. Harper's Ferry. No date; probably 1832.

Resembles in all particulars the Hall's rifle, &c., before described, except as to the bayonet, which consists merely of the blade sliding under the barrel and capable of being withdrawn and fixed by the same means which held it sheathed. Similar to Greener's pencil-case bayonet, &c. Compound implement, screw-driver, &c., carried in a cavity in the back of the butt, closed by an extension of the guard strap hinged at its forward end and held closed or open by a spring. Curious.

Three thousand five hundred and twenty of these arms were purchased for use in the Army during the civil war.

No. 4. Hall's percussion-lock smooth-bore carbine, 1842; caliber, .50.

The Ordnance Department ever since the adoption of the Hall breech-loading rifle in 1818 continued its use in one form or another. (See figure representing rifleman, 1820, with description.) This carbine contains an improvement designed to overcome a serious difficulty to which the former pattern of Hall carbine was liable. In carrying the gun on the shoulder the catch holding down the block would be occasionally released by accident, so that when the soldier brought down the piece to fire, the chamber would be wholly or partly open. If he did not observe this in time the piece was discharged from the open chamber, occasionally cutting off his thumb, if carelessly grasping the stock in front of the chamber. The modification in this instance consists in flattening the head of the catch and spreading it out laterally. While diminishing the risk to the soldier this interfered with the free manipulation of the piece.

No. 5. Hall's smoth-bore carbine; caliber, .52; percussion.

Provided with North's (?) improvement, by which the breech is opened by a side lever instead of by an under catch. The latter was apt to catch in the clothing, &c., and open the breech accidentally, so that a careless soldier in firing might blow off his thumb.

No. 6. Burnside rifle carbine; caliber, .54.

Movable chamber pivoted in front and under the barrel; held closed by means of a cam on transverse shaft operated by side lever. Fired by percussion cap. Used an unprimed metallic cartridge, the case of which covered the joint between the breech-block and the barrel to prevent leakage of gas. A considerable number of these were at one time used by the United States for cavalry.

No. 7. Burnside rifle carbine; caliber, .55.

The breech-block is pivoted at its middle point on a strap hinged to the lower part of the receiver in front. In this particular it resembles the other Burnside carbine of the collection, differing from it in the manner of securing the block when closed. This in the present case is done by means of an ordinary barbed catch on the receiver, connected with a pivoted thumb-piece on the inner side of the guard. This is so arranged that the pressure of the thumb to depress the lever also releases it for its forward movement. Its upper end is engaged with the barbed catch by means of a spring.

Fifty-five thousand five hundred and sixty-seven of these arms were purchased for use in the army during the civil war.

No. 8. Collier's revolving flint-lock rifle; caliber, .53. 1818. Nine square grooves.

Contains a cylinder, like that of the Colt's revolver, with five chambers which are loaded from the muzzle and turned by hand. The mouth of each chamber is recessed sufficiently to receive the end of the barrel, which projects slightly to the rear. A spring behind the cylinder throws it forward when opposite to the barrel and closes the joint. Upon the back of the steel of the lock is formed a hollow chamber containing a quantity of priming powder. By an automatic device, each time that the pan is shut, a measured quantity of the powder is deposited in the pan, the valve in the bottom of the chamber being closed automatically by the forward movement of the pan. In the butt-stock is a loading drift, used to lengthen out the ramrod, which, on account of the pressure of the cylinder, cannot be otherwise sufficiently extended. (See flint-lock magazine; also Maynard primer.)

Loaned by General W. B. Franklin, vice-president and general agent Colt's Patent Fire Arms Company, Hartford, Conn.

No. 9. Colt's revolving rifle; caliber, .56.

The cylinder is revolved automatically by cocking the hammer. This is the main point of difference between the Colt arms and preceding "revolvers," many of which are of great antiquity. All of them, however, require adjustment by hand.

No. 10. Lindner rifle carbine; caliber, .52.

The breech-block is thrown up by a spring lying beneath it, when allowed to move by the revolution of a sleeve which covers the joint between the breech-block and the barrel. This sleeve is cut away, so that, in a certain position, the head of the breech-block may pass the cut. It has a spiral motion in closing, so as to draw the breech-block forward against the barrel. The rear end of the breech-block is loose, simply resting in a socket. Used by the United States during the war of the rebellion.

Eight hundred and ninety-two of these arms were purchased for use in the army during the civil war.

No. 11. Breech-loading rifled repeating parlor carbine. Swiss or Belgian. Caliber, .35; ten shots.

A disk about 2½ inches diameter by three-fourths of an inch thick, containing ten chambers radially disposed, is pivoted in the prolongation of the barrel, on a vertical axis, which is the axis of the disk. These chambers having been loaded with loose ammunition when off the piece, the disk is set in place and keyed there by drawing back the sliding barrel by means of the side lever until the tapered butt of the barrel enters into the mouth of the nearest chamber. This movement of the side lever cocks a concealed hammer beneath the disk, which, when the trigger is pulled, rises to strike the percussion cap with which each chamber is primed. The barrel is then thrown forward again to allow the disk to be again turned for the next shot by hand. Its revolution is checked by a spring pin on the under side of the disk. The chasing on the lid of chamber-piece is very well done, representing a wreath of vine leaves. Barrel hexagonal; fourteen grooves; serrated rifling; stock of ebony or of pear wood dyed black.

No. 12. Perry rifled carbine; caliber, .52; seven grooves. Rebel.

The lever is hinged to the frame at its forward end. At a point further to the rear it is connected with the breech-block by a link passing in front of the joint of the lever. When the lever is depressed this link throws up the mouth of the chambered breech-block to be loaded. Fired by percussion cap. No catch to hold the lever is shown. Workmanship poor.

No. 13. Rebel rifled carbine; caliber, .54.

Movable chamber in breech-block sliding at right angles to barrel opened by a lever beneath the barrel, pivoted at a middle point. The front end of the lever is fastened to the under side of the breech-block by a link. The rear end of the lever is free. By depressing the rear end, the front end is thrown up, carrying with it the breech-block. Fired by a percussion cap; no gas check. Very fair workmanship considering the circumstances of manufacture.

BREECH-LOADING MUSKETS AND RIFLES.

Fixed chambers.

No. 1. Flint-lock smooth-bore musket; caliber, .69; barrel, 4 feet long. No marks.

This gun is opened by giving the barrel a quarter turn to the right, releasing a stud upon its surface from a notch in the frame, and then withdrawing it forward. The end of the barrel is made conical to fit the correspondingly funneled mouth of the chamber. The bearing of the stud is made oblique to force two surfaces together, exactly upon the principle adopted for closing the joint of the Prussian needle-gun, 1847. A small funnel leads into the priming-pan from the front. The cock has an additional thumb-piece in rear of the head, to draw it back by. In this gun the chamber is only *relatively* a movable chamber, the chamber itself remaining fixed, and the barrel sliding away from it to open the gun. The open joint at the junction, which is the main characteristic of the movable chamber, would class this gun with the Hall and others like it, except for classification. The importance of the sliding barrel, outweighs the peculiarity of the open joint. This construction is essential to flint-lock guns, on account of the necessity of having the open end of the chamber closed by the ball, and of having the closed end in immediate contact with the priming. With a percussion lock the cone would have been put on the butt of the barrel, and there would have been no open joint.

No. 2. Sharp and Hankins breech-loading rifle carbine; caliber, .52.

Barrel slides forward on depressing lever, which is connected with the barrel by a link running from a joint midlength of the lever, to a joint underneath the barrel, meant for rim-fire ammunition, using firing pin without spring. The extractor consists of a stud, beveled to the front, pressed up through the bottom of the receiver by a spring underneath it just in front of the base of the breech. As the barrel slides back to close the piece, the rim of the cartridge in the chamber presses down this stud, and passes over it. As the barrel is slid forward after firing, the empty shell is caught by this stud and left behind.

No. 3. Norny's breech-loading alteration of the Springfield rifled musket; caliber, .58.

Opened by drawing back a lever pivoted underneath the stock, in front of the trigger-guard. This lever has a link connecting it with the butt of the barrel, so that by the above operation the entire barrel is slid forward in its bed between the stock and the band. *Loaded* with a cartridge inserted by hand into the chamber. *Closed* by reversing the movement of the lever, which is secured when closed by means of a turn-screw at its forward end. *Fired* by the ordinary side lock, the face of the hammer being prolonged and sharpened to strike the rim of the cartridge. Cartridge extracted by the beveled stud on the face of the breech screw. (See Sharp & Hankins.)

No. 4. Breech-loading needle-rifle; caliber, .53.

Opened by turning crank at side. This slides the barrel forward by means of a rack under the barrel, which engages with a toothed pinion on the crank. Turning the crank cocks the piece by means of a link joining the crank pinion with the tumbler of the lock. It is fired by means of a needle running forward through the powder and igniting the fulminate in the base of the bullet, after the manner of the needle carbine. The envelope of the bullet being consumed, no extractor is required. The origin of this piece is unknown, but supposed to be German. Used to a limited extent during the war of the rebellion.

No. 5. Brook's breech-loading carbine; caliber, .52.

By depressing the lever the barrel is first slid forward and then tipped up in rear; swiveling in a ring formed in the stock-tip. Fires a linen or combustible cartridge, by means of a percussion cap placed by hand.

No. 6. Greene's breech-loading carbine; caliber, .52.

By pressing the forward trigger the barrel may be turned on its own axis until the two lugs at its base are free from the grooves in the receiver, in which they rest when the piece is closed. The barrel is then drawn forward by hand clear of the receiver and turned on an axis parallel to itself and beneath it. By making one-fourth revolution on this axis the chamber is exposed as on the side of the piece and loaded with a linen, paper, or skin cartridge. On returning the barrel to its place in closing the breech, a sharp, hollow duct, fastened to the base of the breech in prolongation of the vent, pierces the base of the cartridge and carries the flame from the primer to the charge. The lugs on the butt of the barrel are somewhat spiral, so as to wedge the barrel tightly against the receiver in closing. The breech is kept closed by means of a small bolt, pressed forward from the face of the receiver by a spring. This enters a corresponding cavity in the base of the barrel. The primer resembles the Maynard in principle. It passes the tape forward by means of a small toothed wheel in the primer-box, made to revolve in one direction only by the cocking of the hammer.

No. 7. Scott or Triplett magazine carbine.

Magazine in butt-stock; barrel revolves on parallel axis beneath it until opposite mouth of magazine, where it receives its charge. (For full description see Ordnance Memoranda XV, or Report Chief of Ordnance, 1873.)

No. 8. Prussian needle-carbine; caliber, .53.

Opened by turning handle backward to the left. This causes the barrel to revolve on a vertical axis at right angles to itself. Fired by a needle passing through the powder to a pellet of fulminate in the base of the ball. (See Ordnance Memoranda XV, or Report of Chief of Ordnance, 1873.)

No. 9. Maynard breech-loading rifle carbine; caliber, .50.

By depressing the lever the connecting link in front of it tips up the rear end of the barrel. The fire is communicated from the vent to an orifice in the base of the cartridge, as in the Burnside carbine. The end of the barrel is chamfered, so as to be removed with the fingers. The cartridge head for this purpose is made extra wide.

Twenty thousand and two of these arms were purchased for use in the Army during the civil war.

No 10. Whitmore, Post & Co. breech-loading rifle carbine; caliber, .52; six ratchet grooves.

By pulling the forward trigger it releases a notch upon its length from engaging with a strap lying within the body of the stock. A flat spring beneath the barrel then raises its butt ready for loading. A lateral extension of the counterbore is intended to receive an extension of the head of the cartridge, by which it is extracted with the fingers, or else is meant to receive the point of a knife, by which the cartridge shell may be picked out. Probably used a metallic cartridge like the Burnside or Maynard, with a small hole in the base for the flame to come through from the percussion cap.

No. 11. Smith breech-loading rifle carbine; caliber, .58; paper ammunition.

Opened by raising brass bolt in front of trigger. This raises the rear end of a very heavy flat spring stretching across the joint between the barrel and the frame above the joint. The rear end of this spring is pierced with a square hole, engaging with a corresponding lug on the frame, and also inclosing a similar lug on the barrel. The end of the barrel is made conical to fit closely and prevent the escape of gas. Fires a self-consuming cartridge by means of an ordinary side lock. The gun, "broken" in this way, could be easily thrown over the bridle arm and loaded with the free hand. Extensively used during the war of the rebellion.

Thirty thousand and sixty-two of these rifles were purchased for use in the Army during the civil war.

No. 12. Smith breech-loading carbine; caliber, .52; metallic ammunition.

Opened by pressing down the rear end of the pivoted lever on the small of the stock back of the spring binding the barrel to the frame. Like the preceding arm, from which it otherwise differs in being adapted for metallic center-fire ammunition. An extractor, hinged upon the axis of the gun, is automatically operated by the opening.

No. 13. F. Wesson's carbine; caliber, .40.

Opened by pulling back forward trigger; this draws out a sliding bolt from its notch in the butt of the barrel, and allows the weight of the barrel to tip it up in

rear. Although the arm fires a rim-fire metallic cartridge, there is no provision made for an extractor.

One hundred and fifty-one of these arms were purchased for use in the army during the civil war.

No. 14. Unknown smooth-bore breech-loading musket; caliber, .58.

Alteration of Springfield muzzle-loader. By depressing the lever which forms the trigger-guard, its forward end, which is prolonged above the pivot, raises the rear end of the barrel, and causes it to revolve about a point just in rear of the lower band, where it is supported on trunnions. The continued backward movement of the upper end of the lever draws back a sliding extractor beneath the barrel against the retractible effort of a spiral spring. The cartridge, which is rim-fire, is exploded by a sharpened prolongation on the face of the hammer; the butt of the barrel and the breech-screw being cut away.

No. 15. Prussian needle-gun; caliber, .60.

Presented by the Prussian Government to the United States, 1868. (See Ordnance Memoranda No. 15, or Report of the Chief of Ordnance, 1873.) This gun was adopted by the Prussian Government in 1847. It fires a paper cartridge, front ignition, the needle striking a pellet of fulminate in the base of the paper sabot which surrounds the ball. There is no gas-check except that resulting from the mechanical fit of the bolt. The Prussian Government has now adopted a modification of this principle, the Mauser rifle, for metallic cartridges. No specimen was obtainable.

No. 16. Prussian needle-rifle.

Essentially like the Prussian needle-gun, but for use with the sword-bayonet.

No. 17. Prussian needle-gun; caliber, .60.

Later model than preceding, the breech bolt being shorter and more compact.

No. 18. Dreyse improved needle-carbine.

An improvement upon the Prussian needle-gun. (See Ordnance Memoranda No. 15, or Report of the Chief of Ordnance, 1873.) Saves one motion in loading, the needle being automatically "cocked" in opening the piece.

No. 19. Needle carbine; caliber, .60.

On the same principle as the famous Prussian needle-gun. Presented by the Prussian Government to the United States. Tip-stock runs to muzzle.

No. 20. French chassepot; caliber, .43.

The handle is bent down so as to be out of the way in cavalry maneuvers. (See Ordnance Memoranda No. 15 and Report of Chief of Ordnance, 1873, for chassepot rifle.) The spare India rubber washer lies next to the charge in firing. It is compressed in length and expanded sideways, so as to press against the sides of the chamber and prevent the escape of gas.

No. 21. French chassepot rifle; caliber, .43.

The French Government is now experimenting with an alteration of this gun, intended for metallic cartridges, called the Gras rifle. (See Report Chief of Ordnance, 1873, or Ordnance Memoranda No. 15.)

No. 22. Hotchkiss breech-loading rifle; caliber, .45.

By raising the handle the bolt is given a quarter-turn to the left, and the piece automatically cocked. The piece resembles in its operation the Ward-Burton musket and the chassepot, which see. It is provided with a half-cock safety-lever in front of

the guard, by which the bolt and the trigger may both be locked when desired. The bearing side of the slot in the receiver is curved, so that in closing the breech the motion of the bolt is gently checked in turning it down into place. This prevents a violent shock against the head of the cartridge.

No. 23. Hotchkiss magazine rifle; caliber, .43.

See Hotchkiss's breech-loading rifle, upon which it is modeled. The only essential features of difference are as follows: The receiver is made deeper, with a second bore below that in which the bolt plays, entering it obliquely at its forward end. In the prolongation of this bore to the rear is the magazine tube, passing through the small of the stock and through the butt-stock. This tube contains the usual coiled spring and follower. The cartridges are inserted into this tube from the front, heads first. At the entrance to the tube the cartridge passes *through* the head of the sear, which is here expanded so as to make a section of the magazine tube. The force of the trigger-spring usually keeps this section somewhat out of the line of the tube, thus preventing the accidental exit of cartridges once introduced into the magazine. The front of this section is flared to the front, so that, as the cartridges are inserted they successively press the section down into line to admit them to the magazine. The section is also drawn into line by the act of pulling the trigger in firing the piece. This allows the exit of a cartridge into the space below the bolt, ready to take the place of the cartridge which has just been fired. When the piece is opened after the shot the foremost cartridge issues from the magazine with sufficient force to partly enter the chamber, into which it is forced by the forward movement of the bolt. This arm contains no stop for the magazine; cartridges which are fired are replaced by inserting fresh ones in the magazine from in front.

No. 24. Palmer breech-loading rifle carbine; caliber, .52. 1865.

The breech is opened by turning up the handle of the bolt and withdrawing it; and closed by inverse means. The bolt is *locked*, when closed, by the threads of a sectional screw on the rearmost end of the bolt engaging with corresponding sections in the receiver, when the handle is turned down. Fired by an ordinary side lock, the hammer striking the cartridge directly on the rim. The cartridge is extracted by a spring extractor lying above the bolt and fastened to it. The ejection is accomplished by a pivoted lever in the side of the receiver, thrown outward by a spring as the empty cartridge shell passes by it. The well of the receiver is cut away to allow the shell to escape to the side. The bolt revolves independent of the extractor.

One thousand and one of these arms were purchased for use in the army during the civil war.

No. 25. Ward-Burton rifled musket; caliber, .50. Model of 1870.

Issued for experimental trial in the field with the Springfield, Remington, and Sharp's arms, 1,000 of each. (See descriptive pamphlets and Ordnance Memoranda No. 15, or Report of Chief of Ordnance 1873.)

No. 26. Ward-Burton magazine musket; caliber, .50.

Withdrawing the bolt brings up a fresh cartridge from the magazine tube under the barrel. (See Ordnance Memoranda No. 15, or Report of Chief of Ordnance, 1873.)

No. 27. Vetterlin (Swiss) magazine rifle; caliber, .44.

Adopted by Switzerland for its "Corps d'élite." A bolt gun, operating a carrier, like that of the Henry rifle, by opening the breech. Turning up the handle cocks the piece. (See Report of Chief of Ordnance, 1873, or Ordnance Memoranda No. 15.)

No. 28. Berdan Russian bolt gun; caliber, .42.

This gun resembles essentially all modern bolt guns intended for metallic cartridges. The description of the Ward-Burton (Ordnance Memoranda No. 15, or Report of Chief of Ordnance, 1873) will give a good general account of it. It differs mainly in matters of detail, especially in the extractor, which depends upon the action of a spiral spring. It is largely, if not generally, adopted by the Russian Government, together with another arm by the same inventor, Col. Hiram Berdan, of New York.

No. 29. Green's smooth-bore breech-loading musket; caliber, .54. 1857.

By depressing the spring in rear of the bolt, a keeper pin inside the receiver is released from a cavity in the bolt in which it was previously engaged. The handle of the bolt is then lifted and withdrawn. A piston, traversing the length of the bolt and attached to the handle, serves to pass the charge forward into place. Being then withdrawn the bolt is locked in place by two lugs at its forward end, engaging with corresponding recesses in the receiver. The piece is fired by a lock beneath the barrel hammer.

No. 30. Beaumont breech-loading rifles; caliber, .44.

Presented to the United States by the Government of the Netherlands. A bolt-gun, cocked automatically by turning up the handle to open the breech. It operates otherwise very much as the chassepot. Its main peculiarity consists in the use of a two-leaved mainspring, like that of the ordinary side-lock, in the handle of the bolt Almost all other bolt-guns use a spiral spring. A safety catch on the right side of the receiver locks the bolt in place after loading, and permits the arm to be carried without danger either of accidental opening or of discharge.

No. 31. Jenks breech loading smooth-bore carbine; caliber, .52. 1842.

Opened by drawing back top lever. By means of a link this draws back a sliding breech-plug, and exposes a round hole in the top of the barrel a little larger than the ball. The ball is inserted through this and allowed to run forward to its seat. The powder is then poured in and pressed forward by reversing the movement of the lever. The forward end of the lever covers this hole when the piece is closed and protects it from the weather. The piece is fired by a side hammer, the comb of which is folded so as to lap over the end of the lever and keep it down. The position of the joints of the link, being in line with the abutment on the tang of the receiver, keeps the breech from blowing open; the hammer is an additional precaution. This arm has no gas-check.

A number of these arms were made for the United States Navy.

No. 32. Morse's smooth-bore breech-loading musket; model about 1858.

Opened by raising the flap, hinged at its rear-most end to the butt of the barrel. This exposes a cavity or well in the barrel, formed by cutting away the portion of it above the bore. The breech-block travels back and forth through this cavity, being moved by a link uniting it to the middle point of the flap. This arm uses a center-fire metallic cartridge (Ordnance Memoranda XIV, Plate 1), the rim of which engages with a notched flat spring traveling to and fro with the breech-block. After closing the piece, the firing-pin, playing through a heavy web on the under side of the flap, is pushed forward by hand, through the hole left in the breech-block. This locks the link by binding the block and flap together, and keeps the breech from opening in case of accidental discharge. The piece is fired by an ordinary side lock; a bolt attached to the tumbler, passing through the back portion of the web on the under side of the flap and striking the firing-pin, drives it against the priming in the base of the cartridge. In case the breech has not already been locked by hand, this secures it by driving forward the firing-pin, as before described, and also by entering the cavity

in the back of the web. The cartridge is extracted by the spring in the well of the receiver before described. There is no provision for its ejection.

It was contemplated to make a number of these guns for issue to the troops, just as the war broke out and compelled a return to the safe and sure principles of the muzzle-loader.

No. 33. Merrill breech-loading rifle carbine; caliber, .62. 1863.

Like the Jenks carbine, except as to the manner of loading; has a spring catch, engaging with rear-sight base; also an ordinary side lock, which also rests against the top lever when down. Meant for prepared paper or skin ammunition, the cartridge being pushed forward by the plunger or breech plug to a point accessible to the fire from the cone. No extractor is required, as the cartridge is all consumed. The breech-plug is faced with copper, probably to serve as a gas-check.

Fourteen thousand four hundred and ninety-five of these arms were purchased for use in the Army during the civil war.

No. 34. Merrill breech-loading rifle musket; caliber, .70.

Resembles Merrill carbine, except that no provision is made for locking the breech by the fall of the hammer.

No. 35. Wilson & Flather Bridesburg alteration of muzzle-loading rifle musket; caliber, .58.

Essentially the same in principle as the Morse. The cartridge is rim-fire, fired by a side lock; the parts not so well proportioned as in the Morse, and the breech not so securely locked as in that arm. This arm is provided with an automatic ejector, rising from the bottom of the receiver, to throw out the cartridge after it has been withdrawn by the extractor.

No. 35. Unknown (Lee?) breech-loading musket; caliber, 52.

By cocking the hammer a parallel projection on the shaft of the tumbler strikes against a hinged stud within the breech-block, first lifts it out of its seat in the receiver, and then draws it back until the breech is fully exposed. The hammer is stopped at the half-cock by a projection on the side of the breech-block, against which it strikes. The block is closed by hand. It is locked when in place by setting into its mortise or seat in the receiver. It is fired by the aforesaid projection on the tumbler-shaft striking against a firing-pin in the front end of the breech-block. The fall of the hammer presses into the front end of the breech-block a pivoted pin, and thus helps to keep it from accidental opening. The extractor is drawn back by the opening of the breech-block. When the extractor gets near its limit its bearing on the ways falls suddenly into a dépression made in the ways, causing the front end of the extractor to rise suddenly and eject the cartridge shell from the receiver. This gun is remarkably ingenious. It contains many interesting points merely hinted at herein. One remarkable feature especially, considering its date, 1863 (?), consists in the absence of screws; the entire breech mechanism, including the lock, having but *one screw*, and that one free from many of the objections to its kind.

No. 37. National breech-loading rifle carbine; caliber, 52.

Opened by depressing the lever-guard. This draws down the rear section of the breech-block out of the way of the front section which, by the continued movement of the lever, is then drawn back and the mouth of the chamber exposed. In closing the lever-guard the rear section of the breech-block returns to its place and transfers the strain from the discharge to the back abutment of the receiver. The withdrawing of the forward section of the breech-block extracts the cartridge by means of two barbed springs on each side of the breech-block. The cartridge is fired by an ordinary back-action side lock, the hammer striking a firing-pin. The withdrawal of the

front section of the breech-block by the lever forces the hammer back to the half-cock the face of the hammer resting against the head of the firing-pin, in contact with the breech-block.

No. 38. Henry repeating carbine; caliber, .44.

Resembles essentially the Winchester rifle, except in the manner of charging the magazine. In this gun it is done from the front, the coiled magazine spring being drawn up into the muzzle section of the magazine tube, this is then swung around to the side, exposing the mouth of the magazine tube. The Winchester magazine tube is loaded from the rear, giving greatly increased facility of manipulation and more protection to the spring.

No. 39. Winchester repeating rifle; caliber, .45.

By depressing the lever the breech-bolt is drawn back, and the carrier, containing a cartridge, raised opposite the chamber. By inverse means the cartridge is passed into the chamber, and the carrier dropped to receive a fresh cartridge. (See Ordnance Memoranda No. 15, or Report of the Chief of Ordnance, 1873.) The difference between this gun and the Henry repeating rifle consists mainly in the manner of charging the magazine. In this gun the charging is done from the rear. The magazine has a hinged lid. This is the first arm of this kind made with an iron frame. It was tested by the Board on Small-Arms, 1873.

No. 40. Winchester repeating rifle; caliber, .42.

As made in quantities for the trade, differs materially from preceding only in having a *spring troughed* lid through which to charge the magazine, instead of a hinged lid.

No. 41. Winchester repeating carbine; caliber, .42.

Essentially the same as before described, except in the arrangement of tip-stock, &c. All these guns carry a screw-joint cleaning-rod in sections in the butt.

No. 42. Stetson magazine rifle; caliber, .45.

Resembles externally and in many of its features the Winchester rifle. It is locked in the operation of closing the lever-guard by a projection on the bolt being thrown upward in front of a corresponding shoulder on the upper side of the frame. (See Ordnance Memoranda No. 15, and Report of the Chief of Ordnance, 1873.)

No. 43. Sharps rifle; caliber, .53, for linen ammunition.

This gun differs from its improved form described in the above reports principally in the absence of the special attributes of arms using metallic ammunition. The cartridge was inserted whole, the rising of the block "shearing" off its base by the sharp edge on its forward face. (Sometimes this was unnecessary; Benton, p. 301.) The cartridge was ignited through a vent in the block in this particular arm by means of the Maynard primer. For a description of the gas-check, see Benton, p. 301. This arm, with various modifications, was for many years the standard breech-loading arm of the United States, being largely used for cavalry carbines. (See Report of the Chief of Ordnance, 1873, or Ordnance Memoranda No. 15.)

No. 44. Sharps rifle carbine; caliber, .52, linen ammunition, with Sharps primer.

The primer consists of a small lenticular disk of fulminate inclosed between two layers of copper foil. A number of these primers are contained in a vertical well or magazine in the front edge of the lock-plate. They lie one above the other, being pressed upward by a spiral spring. As the hammer falls in its descent, the topmost of these primers is thrown forward by a slide connected with the hammer, just far

enough to be "caught on the fly" between the face of hammer and the cone. The action of this primer was very sure.

Eighty thousand five hundred and twelve of these arms were purchased for use in the army during the civil war.

No. 45. Sharps rifle musket; caliber, .50, model 1870, for metallic ammunition.

Fired in competition in the field in 1870, with Remington, Ward-Burton, and Springfield arms of same caliber, 1,000 of each being used. (See Ordnance Memoranda No. 15, or Report of the Chief of Ordnance, 1873.)

No. 46. Sharps carbine; caliber, .50, for metallic ammunition.

Used in competitive trials in the field with Springfield, Remington, and Ward-Burton carbines. (See Report of the Chief of Ordnance, 1873, or Ordnance Memoranda No. 15.)

No. 47. Sharps carbine and primer, coffee-mill in the butt.

A number of these carbines were turned in at the close of the war. They are supposed to have been made in Saint Louis, Mo.

No. 48. Sharps carbine; rebel; caliber, .52.

Made at Richmond, Va., numbered 3505. Without magazine primer. A fair specimen of successful manufacture under difficulties.

No. 49. Comblain rifle; caliber, 43.

Partially adopted by the Belgian Government. By depressing the lever the breech-block slides downward to expose the chamber; the motion of the lever cocks the hammer meanwhile. This is done by means of a projection on the lever just in front of its triple joint with the breech-block and hammer. This presses up a corresponding projection on the front of the hammer just above the triple joint. This action is due to the fact that the motion of the breech-block, which contains the hammer and the entire lock, is constrained by straight grooves while the lever swings on a separate axis in front. A projection on the head of the lever, above the main axis, strikes the front side of a swinging extractor pivoted below the chamber, and operates it. It is understood that nearly all the parts of this mechanism are of phosphor-bronze, which is noted for its strength and hardness.

No. 50. Ballard rifle carbine; caliber, .54.

By depressing the lever the breech-block is caused first to recede from the barrel, and then to drop downward, revolving about a shifting horizontal axis at its lower and rearmost corner. The hammer, which with the other parts of the lock is contained in the breech-block, explodes a rim fire cartridge when it falls. The cartridge shell is extracted by means of a sliding extractor beneath the barrel, moved independently by hand by means of a finger-piece projecting beneath the tip-stock.

Fifteen hundred of these arms were purchased for use in the army during the civil war.

No. 51. Werndl Austrian rifle; caliber, .44.

Opened by turning breech-block sideways by the thumb-piece. The extractor is worked by the spiral groove in the upper surface of the breech-block. A flat spring in rear bears against flat surfaces on the spindle, and both accelerates the movement of the parts and holds the block securely open or closed. Fired by side lock. (See Ordnance Memoranda No. 15, or Report of the Chief of Ordnance, 1873.)

No. 52. Warner rifle carbine; caliber, .52, for metallic ammunition.

The breech-block swings open on an axis parallel to the axis of the barrel and to the right of it. It is held down, when closed, by a spring catch engaging with the frame, and also indirectly by the hammer. The extractor slides under the barrel and is operated independently by hand by means of the finger-piece projecting under the tip-stock. The breech-block and receiver are made of bronze.

Four thousand and one of these arms were purchased for use in the army during the civil war.

No. 53. Snider (English).

Alteration of the Enfield rifle; caliber, .58. Adopted largely in Turkey. Opened by turning block over by thumb-piece on the left. It is held down when closed by a small spring catch in the face of the breech. Fired by means of a central firing-pin, struck by the ordinary side lock. The breech-block when opened is permitted a longitudinal sliding motion along the pin on which it is hinged. This motion is given it by hand after firing, and extracts the cartridge shell by means of a transversal point attached to the front of the breech-block and entering the counter bore. (See Report of United States Commissioners to Paris, 1867, p. 32.)

No. 54. Whitney Phœnix; caliber, .45.

The breech-block swings to the right upon an axis parallel to that of the gun, and to the right of it. When open it strikes a beveled lug on a pivoted extractor, like that of the Springfield system, but moving on a vertical axis and lying beneath the barrel. The breech-block is locked when closed by its position. It is held closed by a spring pin in the face of the rear abutment, the point of which enters a shallow cavity in the back of the breech-block. The nose of the hammer enters a counter-sink around the head of the firing-pin and keeps the piece from opening at the half-cock.

No. 55. Joslyn carbine; caliber, .44.

By pulling out the spring catch on the right side, the breech-block is free to turn over the hinge to the left. A spiral wedge on the breech-block, sheering across the butt of the barrel, gradually extracts the cartridge as the breech-block turns. The breech-block is sustained by shutting partly into a circumferential groove around the butt of the barrel.

Eleven thousand two hundred and sixty-one of these arms were purchased for use in the Army during the civil war.

No. 56. Joslyn rifle; caliber, .50.

See description of Joslyn carbine, caliber .44.

No. 57. Tarpley carbine, patent 1860. (Rebel?) Caliber, .52; paper ammunition.

The breech-block swings to the left when the spring catch on the right side is opened. There is no provision for a gas-check.

No. 58. Collins' alteration of the Springfield muzzle-loading rifle musket; caliber, .58.

The breech-block is opened by liberating a spring catch on its right side and swinging it over to the left. The extractor slides under the well of the receiver, and is moved by a separate trigger beneath the barrel. This section has a cogged section on its upper surface, which meshes into an intermediate pinion between itself and the cogged lower surface of the extractor. This causes a pull on the trigger to slide the extractor backward.

No. 59. Freeman breech-loading musket; caliber, .50.

Opened by swinging back breech-block by the thumb-piece in front. Locked by the position of the breech-block, and by help of hammer. Extraction and ejection by sliding extractor underneath seat of block, which operates in connection with it. (See Report of the Chief of Ordnance, 1873, and Ordnance Memoranda No. 15.)

No. 60. Milbanks' alteration of the Springfield muzzle-loading rifle; caliber, .58.

By pressing in the spring-catch the breech-block is swung out to the right. It is locked when closed by the elongation of the joint-hold, and by the lapping of the hammer over the tail of the breech-block in its fall. The hammer is sustained by passing behind the head of a stud projecting laterally from the side of the barrel at its butt. The extractor is pivoted to the face of the breech-block, from which it is pressed out by a spring which induces it to follow the backward movement of the cartridge.

No. 61. Milbanks' alteration; caliber, .58. (Fenian.)

Opens sideways, as in preceding, from which it differs in the form of the handle for opening the breech, and in the extractor; the latter swinging on the joint-pin of the breech-block. The base of the firing-pin is pressed into a cavity in the face of the breech-screw by the action of the firing-pin spring. This serves as a spring catch to hold the block in place. This arm was used by the Fenians in their raid upon Canada, 1870.

No. 62. Joslyn carbine, No. 1; caliber, .52; paper ammunition.

The breech is closed by a plug at the forward end of a strap, running backward on top the small of the stock. The shape of the plug is conical; it is loose upon the strap, and contains a split ring designed to be expanded by the force of the discharge against the sides of its seat at the mouth of the chamber. This expansion is effected by means of a conical plug, driven into the split ring by the discharge. The locking catch is so connected with the sear that the hammer cannot fall while the breech is open. The breech-block is locked when closed by the locking catch at its rear end.

No. 63. Berdan's alteration of the Springfield muzzle-loading musket; caliber, .58.

The breech-block is locked by a cam-latch resembling that of the Springfield system; also by being permitted a very slight sliding movement backward. For a description of the extractor see Russian Berdan in Ordnance Memoranda No. 15, or Report of the Chief of Ordnance, 1873.

No. 64. Lamson's alteration of the Springfield musket; caliber, .58.

The force of the discharge drives backward bodily the lower (sliding) section of the breech-block against its seat in the face of the breech-screw. This locks the breech. The extractor is like that of the Springfield system, a broad flat spring being used instead of the spiral spring and spindle now employed. The length of the receiver of the Springfield breech-loading musket, caliber, .50, model 1868, forward of the hinge, was intended for the application of such a spring as this. The spiral-spring ejector was adopted, however, in season to render this extra length unnecessary.

No. 65. Miller's alteration of Springfield muzzle-loader; caliber, .58. No. 1.

A bolt, sliding vertically at right angles to the length of the breech-block in its back end, is moved up and down by a tooth on a transverse shaft like the cam-latch

shaft of the Springfield system. This carries it into a recess cut in the face of the breech-screw, independent of the rotation of the block. The extractor is like that of the Springfield system. Its motion is accelerated by being struck near the completion of its motion by the long end of a lever, lying across the top of the breech-block near its front end. The short arm of this lever projects upward, and, striking the hinge of the receiver in opening, throws the long arm quickly against the stud on the extractor and thus accelerates its motion. The sides of the receiver are notably cut away to allow the free escape of gas from defective cartridges.

No. 66. Miller's rifle carbine, No. 2; caliber .50. 1865.

The breech-block, which is hinged above the barrel, is made with an L-shaped arm covering the mouth of the chamber and provided with a tenon entering a mortise in the bottom of the receiver. This mortise is a little longer than the tenon, and receives the lower end of a vertical bolt sliding in the back surface of the breech-block. When this bolt is down the mortise is filled and the breech cannot be opened. When it is lifted sufficient space is given for the tenon to clear the end of the mortise in opening. A spring tends to keep the bolt always down. A wedge-shaped incline on the side of the sliding-bolt passes under the head of the firing-pin and retracts it as the bolt is lifted. A projecting arm at its forward end moves a sliding extractor in the side of the barrel.

No. 67. Miller's alteration of Springfield musket; caliber, .58.

See Miller carbine, which it resembles, except as to the firing-pin retractor, which is omitted in this arm.

No. 68. Springfield breech-loading rifled musket; caliber, .58. Allin's alteration.

Five thousand of these guns were made in 1865, as soon as the return of peace permitted the attention of the Ordnance Department to be directed from the question of the immediate supply of the most easily manufactured arms. This arm is the first of the series of alterations of the muzzle-loading rifle musket which have developed into the Springfield rifle, caliber .45, of the present day. It is opened by raising the cam-latch by means of the thumb-piece as at present, fired by a side lock in the same way, &c. It differs from the present gun mainly in the detail of its parts and in the extractor. This slides back and forth in a groove cut in the side of the barrel. Upon its upper edge it bears a rack into which meshes a series of similar teeth in a curved arm running up from the front of the breech-block. A spring serves to draw it back. The objection to this arrangement was its delicacy and the liability of the stock to being blown away through the cut made for the extractor in case the cartridge-head should burst. Devised by Mr. E. S. Allin, master armorer, United States Armory, Springfield, Mass.

No. 69. Springfield breech-loading rifled musket; caliber, .50. Allin's alteration.

The increased length of extractor and cogged extension arm, due to the increase in length of the cartridge in consequence of its reduced caliber, developed the defects of this system.

No. 70. Springfield breech-loading rifled musket; caliber, .50. Model 1866.

Differs from the Allin alteration in the greater strength of its parts, and in the extractor, which consists of a U-shaped spring against the side of the receiver. One point of this spring projects into the receiver and catches against the rim of the cartridge as the cartridge is passed into the chamber. Closing the breech-block com-

presses this spring, which is released, on opening, with sufficient force to throw out the empty shell. The caliber of this barrel is reduced from .58 to .50 by the insertion and brazing of a lining tube. (See Book of Descriptive Pamphlets for details; or Benton, p. 304.)

No. 71. Springfield breech-loading rifled musket; caliber, .50. Model 1866.

Barrel reduced from caliber .58 by bushing. This lining also serves as a reinforce, considerably increasing the strength of the barrel. The barrel is sawed open to show its construction.

No. 72. Springfield breech-loading rifled musket; caliber, .50. Model 1868.

The main point of the improvement over the last arm consists in the use of a separate receiver for the barrel and parts of the mechanism; and in the improvement of the extractor, which is the same as that now employed. (See Descriptive Pamphlet, and Report of the Chief of Ordnance, 1873, or Ordnance Memoranda No. 15.)

No. 73. Springfield rifle; caliber, .50. Model, 1868.

Struck by lightning when in the hands of a sentinel at Fort Shaw, Montana. Point of bayonet, rear of guard-plate, and lock-plate melted and butt-stock split. Sentinel and two prisoners knocked down without injury.

No. 74. Springfield rifle; caliber, .50. Model 1868.

Turned in as unserviceable from the field. Exhibited to show efficiency of working parts in spite of abuse.

No. 75. Springfield rifle; caliber, .50. Model 1870.

The individual arm tested by the Small-Arms Board which adopted the Springfield system. This arm was fired 622 shots before the Board under the most severe series of tests ever known to have been adopted. It worked well throughout. This differs from the model of 1868 in the length of that part of the receiver forward of the joint. (See Lamson's alteration; also see Ordnance Memoranda No. 15, or Report of the Chief of Ordnance, 1873.)

No. 76. Springfield carbine; caliber, .50. Trial. Model 1870.

This arm was issued for experimental trial in the field with the Sharp's, Remington, and Ward-Burton carbines.

No. 77. Allin's improved Springfield rifle; caliber, .50.

The essential feature of this rifle consists in its dispensing with the number of parts forming the ordinary side lock. The mainspring in this case lies under the receiver. The other parts lie beneath the tang of the breech-screw. (See Stillman's alteration; see also Ordnance Memoranda No. 15, or Report of the Chief of Ordnance, 1873.)

No. 78. Springfield rifle; caliber, .50. Stillman's improvement.

Designed to dispense with the number of parts in the ordinary side lock. All the lock is inclosed in the tang of the breech-screw comprising nine parts.

No. 79. Springfield rifle; caliber, .45. Present model.

This is the standard arm of the United States service. This particular arm is provided with a trowel-bayonet fixed. (See Ordnance Memoranda No. 15, or Report of the Chief of Ordnance, 1873; Springfield No. 99; also Descriptive Pamphlet of Small Arms United States service.)

No. 80. Springfield rifle; caliber, .45.

Skeletonized to show operation of all its moving parts. Attention is particularly called to the ejector.

No. 81. Springfield cadet rifle; caliber, .45.

Is exactly like the service rifle, except in size. As the cadets do not use gun-slings, only the stacking-swivel is shown.

No. 82. Springfield officers' sporting rifle; caliber, .45.

This arm is made for sale to officers of the Army. It is between a carbine and rifle in length of barrel, and has peep and combination globe-sights besides the ordinary service rear-sight. It is also provided with a wooden cleaning rod, and a set lock. The parts of the system are somewhat decorated by engraving. The peculiarity of the set lock consists in its safety, acting as an ordinary lock until purposely set, which is done after cocking the hammer. These are sold to officers at a cost of $36.

No. 83. Springfield rifle; caliber, .45; with Metcalfe's cartridge, block attached.

Designed to hold eight cartridges on the side of the gun in a convenient position for loading rapidly. The block is intended to be thrown away as soon as its contents are exhausted.

No. 84. Hartford Berdan rifle; caliber, .42. Russian.

The breech-block is locked by a bolt driven by a spiral spring, which also strikes the firing pin at the same time. Used in part in the Russian service. (See Report of the Chief of Ordnance, or Ordnance Memoranda No. 15.)

No. 85. Braedlin-Albini rifle; caliber, .44. Belgian.

The breech-block is locked in place by a bolt connected with the hammer, which enters an axial cavity in the block. The firing-pin lies forward of this cavity, and is struck by the bolt when the hammer falls. Opening the breech-block operates a double extractor, which is without an accelerating device. This arm is used by the line of the Belgian army. (See Norton's Report, French Exposition, p. 47.)

No. 86. Millbank-Amsler (Swiss); caliber, .42.

Resembles essentially, though in a crude form, the Springfield system. The cam stretches across the receiver from side to side. It has no spring. There is no ejecting device. The hammer has no half cock.

No. 87. Wanzel rifle; caliber, .58.

By cocking the hammer, a bolt attached to the tumbler is drawn back from its cavity in the body of the breech-block. The breech-block is then raised by the handle on its right. The bolt above referred to locks down the breech-block against the strain of the discharge. The extractor slides along the side of the receiver, being connected with a projection on one of the hinge pieces of the breech-block forward of the joint. The projection is cam-shaped and bears against a flat spring on the side of the receiver. This spring tends to keep the breech-block open until forcibly shut. The hammer strikes a special firing-pin, traversing the block diagonally to the lowest point on the face of the breech-block. The cleaning implements accompany this piece.

No. 88. Elliot carbine; caliber, .45.

Opened and closed by the alternate motions of cocking the hammer. (See Ordnance Memoranda No. 15, or Report of the Chief of Ordnance, 1873.)

No. 89. Lee rifle; caliber, .45.

Opened by pressing forward the hammer. The insertion of the cartridge releases the breech-block which is raised when the hammer is next cocked. The cartridge is extracted and ejected by pressing forward the hammer. One hundred of these, made at the National Armory, are now on trial in the field. (See Report of the Chief of Ordnance, 1873, &c.)

No. 90. Werder Bavarian musket; caliber, 45.

Opened by pressing forward the foremost trigger. Closed by cocking the hammer. A very ingenious mechanism. (See Ordnance Memoranda No. 15, or Report of the Chief of Ordnance, 1873.)

No. 91. Peabody carbine; caliber, .44.

By depressing the lever the front of the breech-block falls, exposing the chamber. The strain of the discharge is transferred directly to the abutment on the frame, the hole through which the axis pin passes being made purposely large. See Report of Chief of Ordnance, 1873, or Ordnance Memoranda No. 15.

No. 92. Martini rifle; caliber, .45; English, of English manufacture.

See the description of the Peabody carbine, from which system this arm was derived. Its main peculiarity consists in the concealed lock cocked by the depression of the lever in opening. The indicator on the side serves to indicate the position of "cocked," and the locking-bolt when drawn back by hand answers the purpose of the ordinary half-cock notch. The upper band carries a stud for the saber bayonet.

See Ordnance Memoranda No. 15, and Report of Chief of Ordnance, 1873.

No. 93. Peabody-Martini rifle; caliber, .45. (Turkish).

As made by the Providence Tool Company, Providence, R. I., for the Turkish Government. It differs from the English-Martini only in the position of the bayonet stud, which is for a triangular bayonet.

No. 94. Peabody-Martini rifle; caliber, .45. (Turkish).

Skeletonized, showing the operation of all the moving parts.

No. 95. Peabody-Martini rifle; caliber, .45.

With Metcalfe's cartridge-block and carrier. (For a description of which see Ordnance Memoranda No. 19, or account of lay figure in light marching order, 1876.)

No. 96. Cosmopolitan carbine, No. 2; caliber, .54.

By depressing the lever the breech-block is first withdrawn from the barrel until a cylindrical tenon on its face is clear of the chamber. It then revolves about an axis, in rear and above it, until the chamber is exposed. This is very ingeniously and simply accomplished. The strain of the discharge is transferred by the head of the lever to the abutment on the frame. The arm uses a paper or linen cartridge, ignited by a percussion cap.

No. 97. Merrill, Latrobe & Thomas.

The arm is loaded with loose ammunition from underneath. The ball being introduced through the hole in the front part of the guard strap, the lever is raised bringing the hole in the breech-block in line with the bore. The ball is then pushed into place by the piston underneath the lever. The powder is similarly treated. The breech-block consists of a transverse pin at the face of the breech, perforated with a hole the size of the bore. The breech-block is locked by its position, and by the spring catch at the rear end of the lever. The charge is fired by the ordinary outside lock, using the Maynard primer.

No. 98. Merrill, Latrobe & Thomas carbine; caliber, .52. (Rebel.)

Same as before described, except that a friction spring and pin hold the lever in place when open.

No. 99. Merrill, Latrobe & Thomas; caliber, .58.

Same as before described, except that the top lever is replaced by a side lever. The construction of the primer magazine is improved.

No. 100. Allen & Wheelock carbine; caliber, .40.

Raising the lever turns the transverse breech-block so that the charge may be inserted through it from the rear. (See Merrill, Latrobe & Thomas.)

No. 101. Symmes carbine; caliber, .54.

By depressing the lever the sectoral breech-block is caused to revolve until the hole through it comes in prolongation of the bore. The cartridge is then inserted, and the lever returned to place. The charge is fired by an ordinary side lock using an arrangement like the Maynard primer. The face of the breech-block contains a recessed platinum gas-check ring.

No. 102. Remington carbine; old model; caliber, .52.

The hammer passes forward in a slot cut in the back of the breech-block. The extraction is accomplished by a stud on the forward surface of the hub of the breech-block. The breech-block is locked against the discharge by means of the hammer, which moves on a different center from that of the block. It receives the thrust of the discharge near the firing point and transfers it to the abutment on the frame. Twenty thousand of these arms were purchased for use in the Army during the civil war.

No. 103. Remington rifle musket; caliber, .50.

This arm was issued for trial in the field in competition with the Springfield, Sharps, and Ward-Burton arms, about 1,000 of each being made for the purpose. See Ordnance Memoranda No. 15, and Report of Chief of Ordnance, 1873.

No. 104. Remington carbine; caliber, .50; made at United States armory, 1870.

Issued for competitive trial in the field, 1870, with the Sharps, Springfield, and Ward-Burton arms.

No. 105. Remington locking rifle; caliber, .50.

Made at the United States armory for issue. In closing the breech the hammer falls forward part way, so as to support the breech-block in case of accidental discharge. It is then recocked and fired as before. See Ordnance Memoranda 15, or Report of Chief of Ordnance, 1873.

No. 106. Remington rifle; caliber, .45.

Made by E. Remington & Sons, Ilion, N. Y. The extractor swings on the same axis as the breech-block. See Remington No. 20, Ordnance Memoranda 15, or Report of Chief of Ordnance, 1873.

No. 107. Remington rifle; caliber, .45.

Made by E. Remington & Sons, Ilion, N. Y. Same as preceding in the operation of the system.

No. 108. Remington carbine; caliber, .45.

Made by E. Remington & Sons, Ilion, N. Y.

No. 109. Remington short rifle; caliber, .45.

Made by E. Remington & Sons, Ilion, N. Y.

No. 110. Remington carbine; caliber, .45; Dutch.

Made at Liege for the Government of the Netherlands. In opening the breech-block the outer end of a small lever, projecting from its back, strikes against the body of the hammer. This retracts the firing-pin, against which the inner end of the lever is resting. The object of this is to withdraw the point of the firing-pin from the face of the breech-block, so that in closing it will not incur the danger of accidentally exploding the cartridge before it is supported by the hammer.

No. 111. "Chick" or Laidley-Emery carbine; caliber, .52.

Opened by drawing back the locking-lever on the right of the breech-block by its thumb-piece.

(1.) This presses back out of the way the locking-brace, which is on the same axis of the hammer.

(2.) The breech-block is then free to move.

(3.) The locking-brace is slit to receive the hammer, and is pivoted on the same axis with it when the breech-block is closed. The locking-brace is thrown forward by an independent spring, and rests beneath the breech-block supporting its rear end.

(4.) A stud on the hub of the breech-block withdraws the cartridge shell.

(See the description of its derivative, the Whitney arm, Ordnance Memoranda No. 15, or Report of Chief of Ordnance, 1873.)

No. 112. Whitney system (improved); caliber, .50.

Derived with modifications from the Laidley-Emery, which see; also Ordnance Memoranda No. 15, or Report of Chief of Ordnance, 1873. By pressing back the thumb-piece the locking brace, which is on the same center as the hammer, is revolved backward, leaving the breech-block free to be turned downward and backward by the continued movement of the thumb-piece. In closing the breech, the locking brace is thrown forward under the back of the block by a spring supporting it from opening in case of accidental discharge. The locking brace is independent of the hammer. This is the essential difference between this system and the Remington.

No. 113. Whitney system (improved).

Skeletonized. See previous description and Ordnance Memoranda No. 15, or Report of Chief of Ordnance, 1873.

No. 114. Miller carbine No. 2; caliber, .38.

A vertical slide in the upper part of the breech-block, just back of the thumb-piece, engages with corresponding notches in the sides of the frame, and supports the breech-block against the discharge. When this slide is raised, the hammer having been previously cocked, the breech may be opened. The extractor swings on the axis of the breech-block. This gun contains a shell made of solid steel. The stock is remarkably beautiful.

No. 115. Dexter rifle; caliber, .50.

Opened by depressing side lever. This draws back the cocking brace inside the frame and causes the breech-block to revolve. See Ordnance Memoranda 15, and Chief of Ordnance Report, 1873.

No. 116. Earle sporting rifle; caliber, .30.

The lower part of the breech-block is formed with a stem running forward underneath the barrel, and terminating at a transverse bearing in front, against which it rests loosely. The back of the breech-block and the continuous portion of the same

are curved from this center. The upper part of the breech-block is formed with a stem running backwards, by which to depress the breech-block in opening against the pressure of the mainspring underneath it. When open (down), the breech-block is caught and held by a notch on the trigger. The cartridge being inserted, by pulling the trigger the breech is closed and the cartridge simultaneously fired by a projecting firing-pin on the face of the breech-block. In firing, the breech-block moves bodily backward under the influence of the discharge against its bearing on the curved surface of the receiver. A sliding extractor in the side of the barrel is withdrawn by means of a curved thumb-piece in rear, to extract the shell. The trigger is a straight piece pivoted on a loose bearing at its upper end at a point below and in rear of the breech-block. On its front surface is cut the notch which engages with the notch on the back of the breech-block to hold the latter down when the piece is open. The trigger is pressed forward by a spiral spring back of it. A double-leaf mainspring underneath the breech-block causes it to operate as a hammer.

No. 117. Spencer magazine carbine; caliber, .52.

The action of depressing the lever opens the breech, and at the same time admits a cartridge from the magazine in rear. A repetition of this movement withdraws the empty shell and loads a new one. The magazine contains seven shots, *rim fire*, to prevent striking fulminate by balls. This arm carries the Stabler attachment. A turn button underneath allows the action of the magazine to be interrupted by limiting the opening of the block, and the arm then used as a single loader; 94,156 of these arms were purchased for use in the Army during the civil war. See Benton, p. 305.

No. 118. Spencer magazine carbine; caliber, .52.

Skeletonized so as to show the operation of all the principal moving parts.

No. 119. Ball magazine carbine; caliber, 50.

The magazine which lies beneath the barrel is loaded from the rear through an aperture in the side of the receiver. As the breech-block is closed it carries forward on a trough formed on its face a cartridge which it has received from the magazine and which it passes into the chamber. The back of this scoop-shaped trough has a semicircular groove for the rim of the cartridge. The piece is fired by a side lock. In opening the piece after firing, the empty shell is withdrawn by means of the semicircular groove above described. When the shell gets opposite to the loading hole it receives a sharp blow from a spring lever opposite the hole on the other side of the frame; this throws it clear of the piece. This lever is operated by the descent of the breech-block. The breech-block is so arranged that once closed it cannot be opened until after the hammer has fallen. This is intended to prevent loss of ammunition, &c. One thousand and one of these arms were purchased for use in the army during the civil war.

No. 120. Evans magazine carbine; caliber, .43.

The principal feature consists of the magazine, which is made in the form of a tube 1¼ inches in diameter, constituting the small of the stock and extending from this position through the butt stock to the butt plate. In this tube revolves a fluted cylinder of 4 flutes; around the cylinder is coiled a spiral wire fastened to the inside of the tube. The pitch of this spiral is equal to the length of a cartridge. A pawl, operated by the breech-block, causes the fluted cylinder to revolve one quarter turn each time that the lever is opened and closed. The flutes of the cylinder are full of cartridges lying longitudinally between the coils of the spiral, so that at each movement of the cylinder a cartridge is delivered in front of the breech-block from the forward end of the cylinder. The breech-block, as it closes, passes this cartridge into the chamber. The joint hole in the breech-block is elongated so as to permit the breech-block in closing to rise until engaged with its proper abutment in the back of the receiver.

The piece is fired by a hammer underneath the guard, cocked by the motion of opening. The extractor plays across the face of the breech-block, nipping the cartridge under the head in the first movement of opening. The ejection is performed laterally by the rotation of the fluted cylinder. The spiral wire keeps the cartridges apart and prevents accidental explosions in the magazine. The magazine contains 34 cartridges. The magazine is charged by dropping in the cartridges at the rear end, working the lever meanwhile. Made by Merwin and Bray, Mechanic Falls, Me. See Ordnance Memoranda 15, or Report of Chief of Ordnance, 1873.

No. 121. Evans magazine rifle; caliber, .44.

See description of Evans carbine and repeater; Chief of Ordnance Report, 1873, or Ordnance Memoranda No. 15.

No. 122. Starr carbine; paper cartridge; caliber, .54.

By depressing the lever the brace in rear of the breech-block is drawn downward by means of a link connecting it with the breech-block. The breech-block is simultaneously caused to revolve downward and backward. The piece is fired by an ordinary side-lock. The face of the breech-block is countersunk annularly so as to give a conical bearing against the butt of the barrel; 25,603 of these arms were purchased for use in the army during the civil war.

No. 123. Starr carbine; paper cartridge; caliber, .54.

Skeletonized to show the operation of all the moving parts.

No. 124. Starr carbine; metallic cartridge; caliber, .54.

See description of carbine for paper cartridge. In the present arm the blow of the hammer is communicated to the cartridge through a cut firing-pin, one section of it lying in the breech-block and one in the brace behind the block. The backward motion of the block draws back the extractor by a very ingenious device, depending upon the action of a bevelled spring-pin in the side of the breech-block, upon a corresponding curved groove in the head of the extractor. This groove is cut away at a certain point, so as to allow a quick release by the spring-pin of the extractor, and its rapid return to its seat under the influence of a retractible spring. A cam spring draws up the lever as the breech is closed.

No. 125. Gross or Cosmopolitan carbine; caliber, —.

By depressing the lever the front section of the breech-block slides back until a cylindrical tenon on its face is clear of the chamber. It then revolves about an axis in front and below it until the chamber is exposed. The strain of the discharge is transferred by the head of the lever to the abutment on the frame. The arm uses a paper or linen cartridge ignited by a percussion-cap. An apron above the block protects the parts from dust, &c., and helps to guide the cartridge in loading.

No. 126. Stevens carbine; caliber, .44.

By pulling back the hook in rear of the trigger-guard, the breech-block is made to fall. It contains all the parts of the lock. The breech is closed by pushing forward the hook. The cartridge extractor swings on the same axis as the block.

No. 127. Miller carbine, No. 3; caliber, .52.

By depressing the lever in rear of the trigger-guard the breech-block is first slightly lifted, until two lugs on each side of it at the top are out of corresponding notches in the sides of the receiver. The breech-block is then caused to revolve so as to expose the chamber. The extractor revolves on the same axis as the block.

No. 128. Miller carbine, No. 4; caliber, .40.

By drawing back the lever in front of the trigger-guard, the breech-block is first slightly lifted, until two lugs on each side of it at the top are out of corresponding notches in the side of the receiver. The breech-block is then caused to revolve so as to expose the chamber. The extractor revolves on the same axis as the block.

No. 129. Unknown carbine (rebel ?); caliber, .52.

By depressing the lever the breech-block is swung down and exposes the face of the chamber. The lever is jointed to the breech-block in rear, so that in closing it a projection near its head may shut into a corresponding cavity in the abutment on the frame. This locks the block. A very thin, wide, steel ring surrounds the orifice of the vent in the face of the breech-block, and enters a corresponding counterbore at the mouth of the chamber when the piece is closed. This is expanded by the action of the gas, and serves as a gas-check. The spring catch for the lever resembles that of the Burnside, and is worthy of attention.

PISTOLS.

The pistols of this collection are arranged as far as possible as follows:

I. Muzzle-loading pistols.
   1st. Flint lock.
   2d. Percussion lock.
II. Breech-loading pistols and revolvers.
   1st. For paper ammunition.
   2d. For metallic ammunition.

In each group the specimens are arranged nearly in the order of their development, either structural or chronological.

MUZZLE-LOADING FLINT-LOCKS.

No. 1. Wheel-lock pistol of the fourteenth century; caliber, .50.

Barrel 19 inches long; total length 2 feet 7 inches. From the Arsenal of Geneva. (See description of wheel-lock musket, *ante*.) The stock is inlaid with engraved bone. The lock is in a very good state of preservation; its interior repays examination both in regard to its ingenuity and ornamentation. The spring which animates the wheel is like that of an ordinary lock. Its branches are brought together by turning the key.

No. 2. Spanish flint-lock petrinal (bell muzzled); caliber, .58.

Diameter at muzzle 1.4 inches; 13-inch barrel. The stock is profusely carved. The butt of the stock is shaped like that of a musket. Loaned by General W. B. Franklin, vice-president and general manager of the Colt's Patent Fire-Arm Manufacturing Company, Hartford, Conn.

No. 3. Spanish flint-lock petrinal (bell muzzled); caliber, .64.

Diameter at the muzzle 1.5 inches; 10-inch barrel. The stock and the metal parts are profusely carved and engraved; the barrel is inlaid with silver. The butt is shaped like that of a musket. Loaned by General W. B. Franklin, vice-president and general manager of the Colt's Patent Fire-Arm Company, Hartford, Conn.

No. 4. Flint-lock pocket pistol; caliber, .42.

Probably contemporaneous with the Revolution. Has a brass barrel. The cock and pan lie on top of the barrel preventing any sight.

No. 5. Albanian flint-lock pistol; caliber, .60.

Twelve-inch barrel. Total length, 19½ inches. The stock is richly inlaid with silver, incrusted with semi-precious stones. The butt and strap, with the muzzle-band, are very artistic specimens of repousse work. Loaned by General W. B. Franklin, vice-president and general manager of the Colt's Fire-Arm Company, Hartford, Conn.

No. 6. Montenegrin flint-lock pistol; caliber, .60.

Barrel 13 inches long; total length 20½ inches. Stock richly carved and inlaid with brass. The shape of the butt is peculiar to Oriental pistols. Loaned by General W. B. Franklin, vice president and general manager of the Colt's Fire-Arm Company, Hartford, Conn.

No. 7. Flint-lock smooth-bore holster pistol; caliber, .54.

R. Johnson, Middletown, Conn., 1836. Barrel 8½ inches long; swivel rod.

MUZZLE-LOADING PERCUSSION LOCKS.

No. 1. Holster smooth-bore pistol, percussion; caliber, .—; model 1842.

Muzzle-loading, with swiveled ramrod. Haston & Co., Middletown, Conn., 1851.

No. 2. Unknown muzzle-loading pistol, percussion; caliber, .28.

The hammer lies underneath the barrel, with the idea of not impeding the sight in aiming.

No. 3. United States Navy smooth-bore Derringer pistol, percussion; caliber, .54.

The lower part of the hammer lies behind the lock-plate and contains the tumbler notches. The essential features of the Derringer pistol were its short, handy barrel and large caliber. Well adapted for a naval engagement.

No. 4. Holster smooth-bore pistol, percussion; caliber, .52.

Made by A. H. Waters & Co., Milbury, Mass.

No. 5. United States smooth-bore pistol-carbine; caliber, .58. Springfield Armory, 1856.

Intended for use either as a pistol or carbine. The butt being detachable at pleasure. Provided with the Maynard primer, a swiveled ramrod, and a rear sight graduated for 400 yards. Although theoretically a good arrangement, it shared the fate of similar combinations.

No. 6. Dragoon pistol, percussion; caliber, .55. Springfield, 1856.

Barrel 12 inches long. Rear sight graduated up to 300 yards. Maynard primer. Intended for use with or without detachable butt stock. See collection of muskets. Swivel ramrod. The Dragoons were intended to fight either on foot or horseback.

No. 7. Prussian smooth-bore pistol, percussion; caliber, .55. Dantzig, 1868.

A bent arm pivoted to the lock-plate in front of the cone, carries at its upper-end guard for the cone. This surrounds the cone and extends a little above it; it is intended to keep the percussion cap from falling off when the piece is carried loaded, the hammer resting upon this guard over the cap, also to save battering the cone in drill. The implements for a pair of these pistols, presented by the Prussian Government, without the screw-driver, weigh 1½ pounds.

No. 8. One pair duelling pistols, percussion; caliber, .55.

Muzzle-loading; barrels 10 inches long; silver mounted; set locks.

REVOLVERS, PAPER AMMUNITION.

No. 1. "Manhattan" revolver (pepper-box), 6 barrels; caliber, .25.

This was one of the first forms assumed by the revolver. The clustering of the barrels has the advantage of preventing the leakage at the joint, common to cylinder revolvers. Its objections are its weight and the difficulty of loading. In this revolver the hammer lies directly above the barrels preventing the possibility of taking aim.

No. 2. Colt's old revolving 6-chamber pistol; caliber, .52.

Probably one of the first made by Colonel Colt. The cylinder is spliced to a sleeve revolving about the central shaft. Upon the rear end of this sleeve is formed a ratchet wheel, with the teeth of which the feed finger, worked by the hammer, engages as the hammer is cocked. The pistol has a sliding sear. The stop motion is substantially as at present. See descriptive pamplet of the small arms of the United States service The barrel had to be removed in order to load this arm. This pistol embodies the essential features of the Colt system, viz: a cylinder revolved automatically by cocking the hammer. Revolvers had long been invented and used, but they depended on an independent rotation of the cylinder by hand. Loaned by General W. B. Franklin, vice-president and general manager of Colt's Fire Arm Company, Hartford, Conn.

No. 3. Colt's revolving pistol; 8 shots; caliber, .42; old model.

Damascus barrel. Trigger falls forward when not in use. The chambers have to be loaded from the front by a separate ramrod, none being attached to the pistol. This is known as a "Paterson" pistol, being one of those first made in quantity by Colonel Colt in Paterson, N. J., 184–. Loaned by General W. B. Franklin, vice-president and general manager of Colt's Fire Arm Company, Hartford, Conn.

No. 4. Colt's revolver; 6 shots; caliber, .44; paper ammunition.

This arm is the type of the revolvers of the non-metallic ammunition class. With the exception of the fluting on the cylinder and the silver plating, it is the form of revolver most generally used during the war. For a description of its operation when adapted to metallic cartridges, see descriptive pamphlet of small arms in the United States service.

No. 5. Leavitt's patent revolver, 1837; 7 shots; caliber, .36.

A rearward prolongation of the cylinder is ended by a beveled gearing meshing into another beveled gear on the shaft of the tumbler. The alternate motions of the hammer cause the last beveled gear to revolve in one direction only by means of a pawl in the side of the tumbler. The cylinder stop consists of a spring pin projecting from the face of the breech and entering small holes in the face of the cylinder. It is drawn back by the tumbler so as to allow the cylinder to revolve. The revolving arrangement may be best seen by removing the lock-plate. The attachment of the barrel is curious. No rammer is attached to the arm. The pistol is somewhat out of repair. Patented in United States next after Colt's, 1836.

No. 6. Leavitt pistol; 6 shots; caliber, .40; for paper ammunition.

Skeletonized by removal of lock so as to show the operation of the revolving apparatus. The stop-pin differs slightly from the other model.

No. 7. Adams revolver (English); 5 shots; caliber, .48.

A self-cocking revolver, the hammer being raised by pulling the trigger. The pistol is out of order, and wanting in some of its parts.

No. 8. Remington revolver; 6 shots; caliber, .44; paper ammunition.

Differs principally from the Colt's revolver in having the frame extending above as well as below the cylinder, making it stronger than the Colt revolver, but heavier.

No. 9. Allen & Wheelock revolver; 6 shots; caliber, .44; paper ammunition.

Its main difference from the ordinary form of the Colt revolver, or of the Remington, which it resembles in having the cylinder inclosed by the frame, consists in the position of the rammer lever, which is turned backward and bent so as to form the trigger guard.

No. 10. Starr revolver; caliber, .44; 6 shots; for metallic ammunition; double trigger.

By pulling the forward trigger the hammer is brought to the half-cock, and the cylinder revolved. By continuing the pull, this trigger is brought against the rear trigger, which causes the hammer to fall. An extractor arm is pivoted below the cylinder, and in rear of it, and swings backward on a horizontal axis. It also serves as a gate to close the mouth of the chambers and keep the cartridges from falling out. On its front side there is a stud projecting forward and hooking into a circumferential groove in the surface of the cylinder, just in front of the line of the cartridge heads. This groove is notched at the seat of each cartridge. After firing each empty shell is brought opposite to the stud and pulled out by rotating the extractor-arm backward by the thumb. This pistol, like most of those which are self-cocking, has a saw handle, the lump on which serves to brace against, in the heavy pull on the trigger which is required to raise the hammer.

No. 11. Starr self-cocking revolver; caliber, .44; 6 shots; paper ammunition.

By continuing the pull on the forward trigger, after the hammer is raised, the back of this trigger strikes against the front of the rear trigger and causes the hammer to fall. (See "Starr self-cocking, metallic ammunition.")

No. 12. Starr revolver; 6 shots; caliber, 48; paper ammunition.

Resembles generally the Colt's revolver, which see. The bed-finger is made extra large. It order to remove the cylinder, the frame is hinged at a point below it and in front, opening at the diagonal corner of the mortise, where it is secured when closed by a transverse screw with a milled head. The cylinder revolves upon centers instead of on a spindle, as in the other revolvers generally.

No. 13. Savage's self-cocking revolver; 6 shots; caliber, .36.

By pulling back the lever in the rear of the trigger the cylinder is first slightly retired from the barrel and then caused to revolve. The hammer is cocked at the same time, when the lever is released. The cylinder moves forward slightly, so that the mouth of the nearest chamber may embrace the butt of the barrel, which for this purpose is made somewhat conical. The cylinder is withdrawn by means of a toggle-joint connected to its rear end, which is lifted by a projection on the upper part of the lever. An arm, attached to this end of the toggle, reaches forward and operates the ratchet. The stop-ratchet is formed on the body of the cylinder back of the cones. The operation of the moving parts, which is very interesting, may be readily seen by removing the plate on the left of the lock.

No. 14. Savage's self-cocking revolver; 6 shots; caliber, .36.

Skeletonized by removal of side plates of lock and stock, to show the operation of all the moving parts.

No. 15. Joslyn's revolver; 6 shots; caliber .44; paper ammunition; skeletonized.

The front end of the tumbler has a connecting rod running up to a point eccentrically placed on a clutch in rear of the cylinder. As the hammer is cocked this clutch makes a partial revolution to the right, carrying with it the cylinder. The clutch has a reciprocating, longitudinal motion, by which it alternately engages with the ratchet and releases its hold.

No. 16. Joslyn's revolver; 5 shots; caliber, .44; paper ammunition.

See description of skeletonized revolver on this principle.

No. 17. Needle revolver; 6 shots; caliber, .36; F. von Dreyse, Lommerda, 1871.

By pulling the trigger the coiled spring surrounding the needle piston is compressed, and the cylinder revolved into place. By continuing the pull on the trigger the needle is darted forward into the charge, igniting the fulminate in the base of the ball. The cylinder stop, on account of its positiveness, is worthy of notice. The chambers are loaded from the front. There is no provision for keeping the cartridge from falling out.

No. 18. Needle pistol; 6 shots; caliber, .36. F. von Dreyse, Lommerda, 1871.

Skeletonized by removing butt stock to show operation of moving parts.

REVOLVERS AND PISTOLS, METALLIC AMMUNITION.

No. 1. Perrin self-cocking revolver; 6 shots; caliber, .45.

The cartridges are inserted through the gate in rear of the cylinder to the right. The tumbler is without any notch, the hammer falling at the moment that the "lift" of the trigger is accomplished.

It may be kept off the cartridges by means of a wedge pressed in by means of a spring so as to block its fall. The wedge is out of the way when the hammer falls in firing. The pistol uses a central-fire cartridge instead of the pin-fire Lefaucheux cartridge, for which it was originally made.

No. 2. Lefaucheux revolver; 6 shots; caliber, .44; metallic (pin-fire) ammunition.

By opening the gate on the right side the rear chambers are exposed and an opportunity given to insert the cartridges. The empty cartridge shells are pushed out to the rear by a sliding rod on the frame. The hammer is cocked by hand and fires a pin-fire cartridge. The cylinder stop consists of a pin playing back and forth in the face of the breech. It arrests the movement of the cylinder by striking against projections on the face of the cylinder between the chambers. In consequence of M. Lefaucheux's early invention of this pin-fire cartridge, this is one of the earliest breech-loading revolvers using metallic ammunition.

No. 3. Colt's revolver; 6 shots; caliber, .44. Altered for metallic ammunition.

The cartridges are introduced through the gate in rear of the cylinder to the right of it. They are ejected by means of a sliding piston on the side of the barrel. See descriptive pamphlet of small-arms in use in the United States service.

No. 4. Colt's revolver; caliber, .44. Altered for metallic ammunition.

Very similar to the Colt's revolver, new model. See descriptive pamphlet of United States Army small-arms.

No. 5. Colt's revolver; caliber, .44. Altered for metallic ammunition.

Resembles closely the new model, caliber, .45, for which see the descriptive pamphlet of small-arms in use in the United States Army.

No. 6. Colt's revolver; new model; 6 chambers; caliber, .45.

The revolver most extensively used in the United States Army. The cylinder of this pistol is inclosed above and below by a solid frame. See descriptive pamphlet of the United States Army small-arms.

No. 7. Remington revolver; caliber, .44. For metallic rim-fire ammunition.

See description of Starr self-cocking revolver, which has the same extractor. The Remington revolvers differ mainly from the Colt's in having the cylinder entirely inclosed in a metal frame. The Colt's revolver is unsupported at the top.

No. 8. Remington revolver; caliber, .44.

Provided with Dr. Hayes's safety slide. A slide passes up in front of the hammer and keeps it off the cartridge until withdrawn by pulling the trigger. The sliding extractor rod is held in place by the stem of the rammer.

No. 9. Remington single-barrel pistol; caliber, .50.

The breech system is the same as that of the Remington No. 20. (Ordnance Memoranda No. 15, or Report Chief of Ordnance, 1873.) A number of these were made for trial in the field. It was thought that the advantage of the large ball which they fire would outweigh the disadvantage of their only firing a single shot.

No. 10. Smith & Wesson revolver; 6 shots; caliber, .44.

By raising the barrel latch in rear of and above the cylinder the pistol may be opened about a horizontal axis diagonally opposite the point of opening. It resembles generally the Schofield Smith & Wesson, which is an improvement upon this arm. See descriptive pamphlet of small-arms in use in the United States service, and Ordnance Notes No. 27.

No. 11. Schofield Smith & Wesson; 6 shots; caliber, .45.

See descriptive pamphlet of small-arms in use in United States Army, and Ordnance Notes No. 27. This arm differs principally from the Smith & Wesson in the form of the barrel latch, which is hinged to the frame instead of to the barrel, of the cylinder catch and of the extractor. The height of the front sight is also reduced by placing it in a groove along the top of the barrel.

No. 12. Christensen's self-cocking 6-shot revolver; caliber, .42; "Danish."

The hinged gate in rear of the right side of the cylinder allows the chambers to be loaded with a pin-fire (Lefaucheux) cartridge. The stop operates against a series of inclined ratchet teeth formed on the body of the cylinder. The trigger folds up when not in use. The butt contains an oil cavity closed by a screw stopper which has an internal stem to take up the oil one drop at a time. An eye is formed in the frame immediately in rear of the hammer, by which the pistol is fastened to the person by a lanyard.

SWORDS, SABERS, KNIVES, ETC.

No. 1. Malay kriss and scabbard.

A bronze knife with a wavy black brass scabbard, with bone mouth; used in Malasia. Presented to the United States Military Academy by General Richard Delafield.

No. 2. Navaja or Spanish knife.

Used even at the present day in Andalusia. It is shifted rapidly from one hand to the other in fighting behind the concealment afforded by the thick felt hat of the country, which is also used to parry the blows of the adversary.

No. 3. Sword belonging to an East Indian chief.

The peculiarity consists of the guard, which is of brass, and, like a half gauntlet, running half way up the wearer's fore-arm. Its use, except to a limited degree, is obviously restricted to thrusting. Presented to the United States Military Academy by General Richard Delafield.

No. 4. Toledo blade.

A dress sword made at Toledo, Spain. Although passably stiff, the blade can be curled up in an annular box 11 inches in diameter. The temper is rather low, as is frequent in Toledo blades. Presented to the United States Military Academy by General Richard Delafield.

No. 5. Rifleman's knife.

Provided for the regiment of mounted rifles, 1846.

No. 6. Cavalry officers' sabers; complete; made at the United States Armory, Springfield, Mass.

Every effort has been made to lighten this saber without impairing its efficiency. The hilt is adorned with castings in high relief.

No 7. Staff and foot officers' swords; complete; made at the United States Armory, Springfield, Mass.

These swords are provided with two scabbards; one nickle-plated for dress purposes; one browned for drills and ordinary use. They are much lighter than the infantry broad swords formerly worn.

ARM CHESTS.

No. 1. Arm chest showing twenty Springfield rifles, caliber, .45, packed for transportation.

The chest with the sides to fold down, so as to illustrate the compact arrangement adopted for transportation. The bayonets occupy the vacant space formed by the guns above them. At the end of the chest is a compartment for holding component parts of the rifles issued for repairs.

No. 2. Arm chest packed with fifty Colt's revolvers.

See remarks upon arm chest for rifles.

CLEANING MATERIALS.

Issued to company commanders for the preservation of the arms in their charge. The box contains oil, scouring composition, leather blacking, whiting, and a chamois skin. A scratch brush is supplied, with instructions for its use in rebrowning the arms. The arrangement of the lid is designed to prevent breakage of hinges, and also to avoid the difficulty sometimes found in closing a sliding lid in wet weather. Cost, about $4.

D.—SMALL-ARM AMMUNITION.

No. 1. Cabinet of small-arm ammunition, prepared at Frankford Arsenal, Pennsylvania.

FIRST DRAWER.

PAPER AMMUNITION, NOT FIXED.

Number.	Name or arm.	Bore.	Powder.	Bullet.	
				Diameter.	Weight.
			Grains.	*Inch.*	*Grains.*
1	Round ball for United States musket, 1842	Smooth	110	.69	412
2	Buck and ball for United States musket, 1842	do	110	.69	435
3	Buckshot for United musket, 1842	do	110	.69	300
4	Round ball for United States rifle, 1840	Rifle	75	.54	220
5	Round ball for United States pistol, 1842	do	60	.54	200
6	Round ball for "Savage" belt pistol	do	65	.50	200
7	Blank for musket, &c	do	60	.58	.....
8	Elongated ball for United States musket, 1842 (Melford sub cal).	Smooth	110	.69	420
9	Elongated ball for Austrian rifle musket	Rifle	75	.71	685
10	Elongated ball for Belgian, &c., rifle musket	do	70	.70	765
11	Elongated ball for United States rifle musket, 1842	do	80	.69	730
12	do	do	80	.68	640
13	Elongated ball for Sringfield rifle musket, 1863	do	60	.58	480
14	Elongated ball for Springfield and Enfield	do	60	.577	495
15	do	do	50	.57	530
16	Elongated ball for Springfield and Enfield, Williams, 1st	do	65	.57	565
17	Elongated ball for Springfield and Enfield, Williams, 2d	do	60	.57	465
18	Elongated ball for Springfield and Enfield, English	do	60	.568	530
19	Elongated ball for United States rifle, 1840	do	60	.54	570
20	do	do	60	.52	455
21	Elongated ball for Green B. L. rifle	do	70	.54	410
22	Elongated ball for United States pistol, 1840	do	30	.54	410
23	Elongated ball for United States pistol carbine	do	40	.58	450
24	Elongated ball for Colt's, &c., army revolver	do	25	.44	205
25	Elongated ball for Colt's navy revolver	do	15	.36	150

SECOND DRAWER.

PAPER AMMUNITION, FIXED.

Number.	Name or arm.	Powder.	Bullet.	
			Diameter.	Weight.
		Grains.	*Inch.*	*Grains.*
26	Merrit's for rifle musket, 1842, &c	60	.69	720
27	Merrit's for musketoon	50	.69	715
28	Merrit's for Springfield rifle musket	50	.58	455
29	Merrit's for Merrit's rifle	50	.56	425
30	Merrit's for Merrit's carbine	40	.56	420
31	Merrit's for Merrit's carbine, United States make	40	.56	420
32	Sharps for Sharps rifle, cal. .54	60	.55	465
33	Sharps for Sharps rifle, cal. .45	70	.47	260
34	Sharps for Sharps rifle, cal. .40	45	.41	170
35	Sharps for Sharps carbine	55	.52	450
36	Colt's for Colt's revolving rifle	45	.56	490
37	Colt's for Colt's revolving pistol carbine	20	.44	260
38	Colt's for Colt's revolver, army	17	.44	260
39	Colt's for Colt's revolver, navy	12	.36	135
40	Savage revolver, navy	10	.36	150

SECOND DRAWER—Continued.

PAPER AMMUNITION, FIXED—Continued.

Number.	Name or arm.	Powder.	Bullet.	
			Diameter.	Weight.
		Grains.	*Inch.*	*Grains.*
41	Inserted paper for Springfield rifle musket, &c	55	.58	475
42	Hall's rifle	40	.54	395
43	Chadwick's for Mississippi rifle, &c	50	.54	420
44	Gardener's shell for Springfield rifle musket, &c	60	.58	450
45	Rebel inserted paper for Enfield rifle musket, &c	70	.577	500
46	Shaler's three-bullet, for Springfield rifle musket, &c	55	.58	610
	Gun-cotton, paper:			
47	Johnson & Dow's combustible paper for Springfield rifle musket, &c.	60	.58	500
48	Johnson & Dow's combustible paper for Enfield rifle musket	60	.574	480
49	Johnson & Dow's combustible paper for Sharps carbine	50	.52	445
50	Johnson & Dow's combustible paper for army revolver	25	.44	240
51	Johnson & Dow's combustible paper for navy revolver	17	.36	150
52	Linen and paper for Sharps carbine	60	.52	450
53	Linen and paper for Starr's carbine	50	.54	430
54	Linen and paper for Union cartridge	40	.54	390

THIRD DRAWER.

TRANSITION, FIXED.

Number.	Name or arm.	Description.	Powder.	Bullet.	
				Diameter.	Weight.
			Grains.	*Inch.*	*Grains.*
55	Hazard compressed for R. M., 1842	Collodion varnish	70	.69	745
56	Hazard compressed Sp. R. M., &c	do	60	.577	490
57	Hazard compressed Sp. Williams ball	do	60	.57	465
58	Hazard compressed Colt's rifle	do	55	.58	480
59	Hazard compressed United States rifle, 1840.	do	70	.54	450
60	Hazard compressed Sharps carbine	do	50	.52	450
61	Hazard compressed army revolver	do	25	.44	210
62	Hazard compressed navy revolver	do	21	.36	140
63	Hayes compressed for rifle	Skin wrapped	60	.54	410
64	Hayes compressed army revolver	do	22	.44	205
65	Hayes compressed navy revolver	do	17	.36	150
66	Hotchkiss compressed for army revolver.	do	22	.44	210
67	Hotchkiss compressed for navy revolver.	do	17	.36	150
68	Hotchkiss compressed Requa battery	do	65	.54	390
69	Hotchkiss compressed Savage navy revolver.	do	10	.36	150
70	Bartholow's compressed for S. B. musket, 1842.	Silk and shellac	65	.69	500
71	Bartholow's compressed R. musket, 1842.	do	70	.69	750
72	Bartholow's compressed Sp. R. musket	do	65	.58	490
73	Bartholow's compressed army revolver	do	20	.44	260
74	Bartholow's compressed navy revolver	do	14	.36	140
75	Smith's rubber for Smith's carbine	Rubber case	40	.50	380
76	Poultney's foil for Smith's carbine	Foil inside of paper	40	.50	380
77	Poultney's foil for Smith's carbine	do	40	.50	380
78	Poultney's foil for Smith's carbine, small chamber.	do	40	.50	380
79	Poultney's foil for Burnside carbine	do	40	.54	370
80	Poultney's foil for Maynard's carbine	do	40	.50	330
81	Poultney's foil for Gallagher's rifle and carbine.	do	60	.50	440
82	Soldered foil, Gallagher's carbine	Foil soldered	60	.50	410
83	Jackson's tin, &c., Gallagher's carbine	Paper over tin	55	.50	430
84	Gallagher's brass, Gallagher's carbine	Brass, lined with paper	60	.50	435
85	Gallagher's brass, Gallagher's carbine	Brass	60	.50	435
86	Burnside for Burnside carbine	do	48	.54	380
87	Maynard for Maynard carbine	do	40	.50	340
88	Berdan, sporting, 1865	Paper, brass base	.....	.55	.....
89	Gun-cotton, Austrian	Woven on stick	26	.58	526
90	Gun-cotton, Austrian, with button	do	20	.53	410
91	Barlow gun-cotton paper	Charge, rolled paper	40	.57	540

FOURTH DRAWER.

RIM PRIMED AND MISCELLANEOUS.

SECTION I.—CALIBER, ".50, SERVICE MUSKET SIZE.

No.	Description.
92	Poultney (Crispin) foil. Brass foil with iron base, and separate brass pocket inserted, clinching the reinforcing wad. Ord. Mem. No. 14, plate xlviii.
93	Poultney (Crispin) foil. Zinc foil, with iron base and separate brass pocket inserted, not clinching the reinforcing wad.
94	Poultney (Crispin) foil. Brass foil with brass base in one piece with the pocket, which is impressed.
95	Hotchkiss solid head. Pocket like Martin, but pressed up from solid base, inclosing small anvil of various patterns. Ord. Mem. No. 14, plate liv.
96	Hotchkiss solid head reloader. Pocket and Berdan return anvil pressed up from solid base.
97	Remington (Martin base). Service as made by Remington in 1872 for use in his arm on trial in the field. F. A. Am. No. 173.
98	Remington, 1874. Reinforcing cap on ring of binders board around pocket. F. A. Am. No. 337.
99	Winchester (Milbank primer). Thick-folded flange. The primer is a flanged percussion cap inserted in a pocket without anvil. F. A. Am. No. 291. Reported on April 29, 1873. Ord. Mem. No. 14, plate xxxv.
100	United States Cartridge Company. Solid head inside primed. Priming in an inside pocket pressed up from the solid metal of the base, the walls of the pocket subsequently closed down upon the priming forming the anvil; cast bullet. F. A. Am. No. 106. Reported on August 8, 1870. Ord. Mem. No. 14, plate lvi.
101	United States Cartridge Company. Solid head outside primed as priming in a closed copper capsule inserted in a shallow outside pocket without anvil. F. A. Am. No. 281. Reported on January 8 and February 4, 1873. Ord. Mem. No. 14, plate lix.
102	United States Cartridge Company. Solid head outside primed as furnished on order for 2,000,000 of November 24, 1873, differs from last in the base being convex and thicker, and the bullet longer and more deeply cannelured. Priming capsules perforated with two vents. F. A. Am. No. 388. Reported on (inspection) January 7, 1874, *et seq.*
103	Union Cartridge Company (Martin base). F. A. Am. No. 174. Tested November 2, 1871.
104	Berdan, early form. Brass case, folded flange, shallow outside pocket. The burr of the vent forming the anvil. Date unknown.
105	Union Cartridge Company (Berdan), as furnished on order for 2,500,000, of April 2, and November 24, 1873. Reinforce ring and return nipple anvil of the Berdan system. F. A. Am. No. 296. Reported on (inspection) August 4, 1873, *et seq.*

SECTION II.—MISCELLANEOUS CENTER PRIMED MUSKET AND CARBINE CARTRIDGES.

106	Berdan. Early form for ".57 caliber. Inserted outside pocket containing a disk-shaped capsule of priming and side teat; patented 1866. Ord. Mem. No. 14, plate xxxix C.
107	Berdan. Early form for ".57 caliber. Impressed shallow outside pocket and cap. The burr of the vent forming the anvil made after seeing the impressed pocket of "Benét" cartridge at Frankford Arsenal.
108	Berdan. Early form for ".44 caliber. Impressed shallow cup, closed with primed disk, the burr of the vent forming the anvil (1867).
109	Berdan, as made by the Union Cartridge Company, for Russian Government ".42 caliber; charge, 77 grains; bullet, 375 grains. Brass bottle-shaped case, re-enforcing ring, and return anvil pocket F. A. Am. No. 40 and 159. Reported on (Small-arms, class 6), January 4, February 2, and February 22, 1870, also tested by Small-Arms Caliber Board as No. 32 of their report. Ord. Mem. No. 14, plate xxxix X.
110	Berdan, as made by the Union Cartridge Company for Ward-Burton, ".45 caliber; charge, 85 grains; bullet, 400 grains. Berdan base and priming. F. A. Am. No. 175. Reported on (gun and ammunition) by Board at Frankford Arsenal, November 27, 1871.
111	Berdan, as made by Union Cartridge Company for Ernest's ".45 caliber rifle; charge, 52 grains; bullet, 290 grains. F. A. Am. No. 211. Rifle failed utterly; no report.
112	Mead's explosive bullet cartridge, ".50 caliber. General service dimensions. Berdan case. Charge stated to be 70 grains. Bullet with copper capsules in front. Fired in Gatling gun 1874. Mead's patent, December 10, 1872. F. A. Am. No. 345.
113	Remington make, cup anvil for navy carbine, model 1868. Thin tin cap vents not retinned. Cast bullet confused with Frankford Arsenal ammunition (No. 451) for same arm. F. A. Am. No. 125. Reported on November 15, 1870.
114	United States Cartridge Company. Solid head front lubricant as proposed to be made for the navy like their army cartridge in all respects except length of case (2.35 inches). Space in front of bullet filled with lubricant. F. A. Am. No. 286. Tested April 11, 1873. Ord. Mem. No. 14, plate lx.
115	Winchester solid head, ".45 caliber, bottle-shaped, very thick, solid base and flange, outside pocket and cap with cruciform anvil, 1874. F. A. Am. No. 339.
116	Morse's arch anvil, made for navy, 1860. Patented 1858. Ord. Mem. No. 14, plate i.
117	Bolt anvil, unknown, cap perforating an India-rubber base like Morse's.
118	Williams rifle, center-fire, disk anvil, crimped into flange; Williams bullet.
119	Covered pocket paper case with metallic base and outside pocket for cap and anvil, the cap and entire base protected by a metallic cover that forms the flange.

FOURTH DRAWER—Continued.

SECTION III.—RIM-FIRE MUSKET AND CARBINE CARTRIDGES, VARIOUS MAKES. ILLUSTRATIVE.

No.	Description.
120	".58 caliber for Allen alteration of Springfield rifle musket, straight case, rim-fire; charge 60 grains musket powder. Bullet, 500 grains, made at National Armory, 1865.
121	".50 caliber, straight case, rim fire; charge 60 grains musket powder; bullet, 400 grains. Made at National Armory 1865.
122	".50 caliber, bottle-shaped case, rim fire; case .58 inch diameter, charge 65 grains; bullet, 480 grains. Made at National Armory, May 1866. Experimental.
123	".45 caliber, straight case, rim fire; case .50 inch diameter, charge 65 grains; bullet, 480 grains. Made at National Armory, May, 1866. Colonel Laidley's Experimental.
124	".45 caliber, bottle-shaped case, rim fire; case .54 inch diameter, charge 70 grains; bullet, 480 grains. Made at National Armory, May, 1866. Colonel Laidley's Experimental.
125	".44 caliber, straight case, rim fire; charge, 45 grains; bullet, 500 grains. Made at National Armory, 1865–'66. Colonel Laidley's Experimental No. 2.
126	".44 caliber, bottle-shaped case, rim fire; charge, 45 grains; bullet, 350 grains. Made at National Armory, 1865–'66. Colonel Laidley's Experimental No. 4.
127	".44 caliber, bottle-shaped case, rim fire; charge, 40 grains; bullet, 300 grains. Made at National Armory, 1865–'66. Colonel Laidley's Experimental No. 5.
128	".44 caliber, bottle-shaped case, rim fire; charge, 40 grains; bullet, 350 grains. Made at National Armory, 1865–'66. Colonel Laidley's Experimental No. 6.
129	".44 caliber, bottle-shaped case, rim fire; charge, 40 grains; bullet, 300 grains. Made at National Armory, 1865–'66. Colonel Laidley's Experimental No. 6 *bis*.
130	".50 caliber, straight case, rim fire; charge, 55 grains; bullet, 500 grains. Made at National Armory, 1865–'66. Colonel Laidley's Experimental No. 8.
131	Spencer carbine, as made at Frankford Arsenal, 1865–'66; charge, 40 grains; bullet, 450 grains. Ord. Mem. No. 14, plate iv.
132	Spencer carbine, as made by Leet & Co., 1865; charge, 40 grains; bullet, 395 grains. F. A. Am. No. 99. Tested April 14, 1870.
133	Spencer carbine, &c., as made by Smith & Wesson, 1865, for various arms; charge, 40 grains; bullet, 440 grains.
134	Sharp & Hankins carbine by Leet & Co., 1865; charge, 55 grains; bullet, 460 grains.
135	Ballard's carbine, &c., caliber ".44, as made by Smith & Wesson, for various small caliber carbines, 1865; charge, 25 grains; bullet, 205 grains.
136	Henry carbine, caliber ".44, as made by Henry Rifle Company, 1864; charge, 30 grains; bullet, 210 grains.

SECTION IV.—PISTOL CARTRIDGES BY VARIOUS MAKERS.

137	Inside cap bolt anvil, single arch, ".44 caliber.
138	Inside cap bolt anvil, double arch, ".44 caliber.
139	Outside cap, solid base, ".44 caliber.
140	Outside cap, center flanged, ".36 caliber.
141	Outside cap, front flanged ".30 caliber, front lubricant.
142	Outside cap, square case, ".36 caliber, nipple exposed.
143	Teat primed, ".44 caliber, spheroidal base; cylindrical teat; front flanged; front lubricant.
144	Teat primed, ".36 caliber, spheroidal base; flattened teat; front flanged; front lubricant; made by National Arms Company, New York, 1860. Ord. Mem. No. 14, plate lxiii, fig. 3.
145	Teat primed, ".36 caliber; flat base; flattened teat; front flanged; front lubricant.
146	Rim primed, ".40 caliber; without flange; concave base; front lubricant. Ord. Mem. No. 14, plate lxii, fig. 5.
147	Rim primed, ".30 caliber; front flanged; concave base; front lubricant.
148	Rim primed, ".24 caliber; without flange; solid base; front lubricant; Ord. Mem. No. 14, plate lxii, fig. 6.
149	Rim primed, ".30 caliber; center flanged; spheroidal frustum base.

FIFTH DRAWER.

METALLIC, ETC., CARTRIDGES. FOREIGN AND SPORTING.

No.	Description.
150	English Boxer Snyder, caliber ".57; parts and stages of manufactures, showing sealed front cavity in bullet, &c.
151	English Boxer Snyder, caliber ".50; paper and foil.
152	English Boxer Henry, caliber ".45; long case, foil and paper.
153	English Boxer Henry, caliber ".45; long case, foil only.
154	English Boxer Henry, caliber ".45; bottle-shaped case; foil powder, 85 grains; musket bullet hardened, 484 grains. F. A. Am. No. 275, used by Small-Arms Caliber Board 1872. No. 51 of their Report. Ord. Mem. No. 14, plate xlix.
155	English Boxer Henry, caliber ".45; bottle-shaped case; foil shortened as made by Eley. F. A. Am. No. 285.

FIFTH DRAWER—Continued.

METALLIC, ETC., CARTRIDGES, FOREIGN AND SPORTING—Continued.

No.	Description.
156	French chassepot, paper; caliber *circa* ".45; powder, 74 grains; rifle-bullet, lead, 388 grains. F. A. Am. No. 332.
157	French mitrailleuse, pasteboard, with metal base; caliber *circa* ".50; powder, 180 grains; compressed in 6 short cylinders; bullet, lead, 750 grains. F. A. Am. No. 333.
158	Prussian needle gun, paper; cylinder choked in front of bullet; powder, 74 grains; rifle bullet, egg-shaped, 325 grains, in sabot; primed on base. F. A. Am. No. 282.
159	Prussian needle gun; explosive bullet substantially like above, but bullet charged and explosible by blow from front; powder, 70 grains; rifle bullet, 431 grains, charged. F. A. Am. No. 330.
160	Prussian new metallic; solid base flange in advance of bottom powder. Bullet, patched, 438 grains. F. A. Am. No. 331.
161	Russian, made in Russia; phosphor-bronze case; Berdan's return pocket anvil; powder, *circa* 80 grains; musket bullet circa, 375 grains, patched. Lubricant at first a disk on base.
162	Russian, made in United States, by Union Cartridge Company, of Bridgeport, Conn. Brass, caliber, ".42; bullet, lead, 373 grains, patched; powder, musket, 77 grains. Lubricant disk on base and dipped. F. A. Am. Nos. 40 and 159. Reported on January 4 and February 2 and 22, 1870.
163	Austrian "Werndl," copper annular anvil in outside pocket; caliber, *circa* ".42; powder, *circa* 65 grains; musket bullet, cast-lead, 318 grains. F. A. Am. No. 277. Fired by Small-Arms Caliber Board 1872, and No. 53 of their report.
164	Dutch Beaumont rifle musket, caliber ".45; brass solid head, pocket cap and anvil priming; anvil with case to push out the old cap in reloading; powder, 68 grains; musket bullet, 337 grains. F. A. Am. No. 247. Fired Small-Arms Caliber Board 1872, No. 31 of their report. Ord. Mem. No. 14, plate lvii.
165	Dutch carbine, caliber ".45; brass, folded head with re-enforcing ring; priming like last; powder, 50 grains; musket bullet, 337 grains. F. A. Am. No. 248. Ord. Mem. No. 14, plate lviii.
166	Swiss "Vetterlin, ".41 caliber; case copper, rim primed; powder, 60 grains; musket bullet cast lead, 312 grains. F. A. Am. No. 276. Fired by Small-Arms Caliber Board 1872, No. 52 of their report.
167	Berdan sporting, for shot; return pocket anvil, priming brass. Made by United States Cartridge Company.
168	Eley sporting, for shot; pocket and anvil cap primed; pasteboard, with metal base No. 12.
169	Eley sporting, for shot; pocket and anvil cap primed; pasteboard, with metal base No. 20.
170	Eley sporting, for shot; Lefaucheux priming; pasteboard, with metal base No. 10.
171	Leet sporting, for shot; pocket and anvil cap primed; pasteboard, re-enforced with foil near metallic base.
172	Leet sporting, for shot; Lefaucheux priming; pasteboard, re-enforced with foil near metallic base.
173	Leet sporting; pocket and anvil cap primed; pasteboard, re-enforced whole length with foil metallic base.
174	Lefaucheux pistol cartridges, 3 calibers.

SIXTH DRAWER.

MODIFICATION OF CHARGE.

[Caliber .50, cartridges.]

No.	Description.
175	Oriental musket powder, 70 grains, loose; sp. gr., 1.692. F. A. Am. No. 67, &c. Reported on March 28, 1870, &c.
176	Hazard musket powder, 70 grains, loose; sp. gr., 1.774. F. A. Am. No. 68, &c. Reported on March 28, 1870, &c.
177	Du Pont musket powder, 70 grains, loose; sp. gr., 1.614. F. A. Am. No. 212. Reported on.
178	Du Pont rifle powder, 70 grains loose; sp. gr., 1.710. F. A. Am. No. 213.
179	Oriental musket powder, 70 grains, compressed from front; perforated, 1.17 inches long. F. A. Am. No. 50. Reported on March 28, 1870.
180	Oriental musket powder, 70 grains, compressed from front; perforated, 1.07 inches long. F. A. Am. No. 51. Reported on March 28, 1870.
181	Oriental musket powder, 70 grains, compressed from front; perforated, .97 inch long. F. A. Am. No. 62. Reported on March 28, 1870.
182	Oriental musket powder, 70 grains, compressed from front; perforated, .87 inch long. F. A. Am. No. 63. Reported on March 28, 1870.
183	Oriental musket powder, 70 grains, compressed from rear; perforated, 1.17 inches long. F. A. Am. No. 42. Reported on March 28, 1870.
184	Oriental musket powder, 70 grains, compressed from rear; perforated, 1.07 inches long. F. A. Am. No. 43. Reported on March 28, 1870.
185	Oriental musket powder, 70 grains, compressed from rear; perforated, .97 inch long. F. A. Am. No. 44. Reported on March 28, 1870.
186	Oriental musket powder, 70 grains, compressed from rear; perforated, .87 inch long. F. A. Am. No. 45. Reported on March 28, 1870.
187	Oriental musket powder, 70 grains, compressed from both ends; perforated, 1.17 inches long. F. A. Am. No. 30. Reported on March 28, 1870.
188	Oriental musket powder, 70 grains, compressed from both ends; perforated, 1.07 inches long. F. A. Am. No. 31. Reported on March 28, 1870.
189	Oriental musket powder, 70 grains, compressed from both ends; perforated, .97 inch long. F. A. Am. No. 32. Reported on March 28, 1870.

SIXTH DRAWER—Continued.

MODIFICATION OF CHARGE—Continued.

No.	Description.
190	Oriental musket powder, 70 grains, compressed from both ends; perforated, .87 inch long. F. A. Am. No. 33. Reported on March 28, 1870.
191	Oriental musket powder, 70 grains, compressed from front; conical rear cavity, 1.17 inches long. F. A. Am. No. 52. Reported on March 28, 1870.
192	Oriental musket powder, 70 grains, compressed from front; conical rear cavity, 1.07 inches long. F. A. Am. No. 53. Reported on March 28, 1870.
193	Oriental musket powder, 70 grains, compressed from front; conical rear cavity, .97 inch long. F. A. Am. No. 64. Reported on March 28, 1870.
194	Oriental musket powder, 70 grains, compressed from front; conical rear cavity, .87 inch long. F. A. Am. No. 65. Reported on March 28, 1870.
195	Oriental musket powder, 70 grains, compressed from rear; conical rear cavity, 1.17 inches long. F. A. Am. No. 46. Reported on March 28, 1870.
196	Oriental musket powder, 70 grains, compressed from rear; conical rear cavity, 1.07 inches long. F. A. Am. No. 47. Reported on March 28, 1870.
197	Oriental musket powder, 70 grains, compressed from rear; conical rear cavity, .97 inch long. F. A. Am. No. 48. Reported on March 28, 1870.
198	Oriental musket powder, 70 grains, compressed from rear; conical rear cavity, .87 inch long. F. A. Am. No. 49. Reported on March 28, 1870.
199	Oriental musket powder, 70 grains, compressed from both ends; conical rear cavity, 1.17 inches long. F. A. Am. No. 35. Reported on March 28, 1870.
200	Oriental musket powder, 70 grains, compressed from both ends; conical rear cavity, 1.07 inches long. F. A. Am. No. 36. Reported on March 28, 1870.
201	Oriental musket powder, 70 grains, compressed from both ends; conical rear cavity, .97 inch long. F. A. Am. No. 37. Reported on March 28, 1870.
202	Oriental musket powder, 70 grains, compressed from both ends; conical rear cavity, .87 inch long. F. A. Am. No. 38. Reported on March 28, 1870.
203	Hazard's musket powder, 70 grains, compressed from front; perforated, 1.17 inches long. F. A. Am. No. 70. Reported on March 28, 1870.
204	Hazard's musket powder, 70 grains, compressed from front; perforated, 1.07 inches long. F. A. Am. No. 71. Reported on March 28, 1870.
205	Hazard's musket powder, 70 grains, compressed from front; perforated, .97 inch long. F. A. Am. No. 72. Reported on March 28, 1870.
206	Hazard's musket powder, 70 grains, compressed from rear; perforated, 1.17 inches long. F. A. Am. No. 54. Reported on March 28, 1870.
207	Hazard's musket powder, 70 grains, compressed from rear; perforated, 1.07 inches long. F. A. Am. No. 56. Reported on March 28, 1870.
208	Hazard's musket powder, 70 grains, compressed from rear; perforated, .97 inch long. F. A. Am. No. 58. Reported on March 28, 1870.
209	Hazard's musket powder, 70 grains, compressed from both ends; perforated, 1.17 inches long. F. A. Am. No. 76. Reported on March 28, 1870.
210	Hazard's musket powder, 70 grains, compressed from both ends; perforated, 1.07 inches long. F. A. Am. No. 77. Reported on March 28, 1870.
211	Hazard's musket powder, 70 grains, compressed from both ends; perforated, .97 inch long. F. A. Am. No. 78. Reported on March 28, 1870.
12	Hazard's musket powder, 70 grains, compressed from front; conical rear cavity, 1.17 inches long. F. A. Am. No. 73. Reported on March 28, 1870.
213	Hazard's musket powder, 70 grains, compressed from front; conical rear cavity, 1.07 inches long. F. A. Am. No. 74. Reported on March 28, 1870.
214	Hazard's musket powder, 70 grains, compressed from front; conical rear cavity, .97 inch long. F. A. Am. No. 75. Reported on March 28, 1870.
215	Hazard's musket powder, 70 grains, compressed from rear; conical rear cavity, 1.17 inches long. F. A. Am. No. 55. Reported on March 28, 1870.
216	Hazard's musket powder, 70 grains, compressed from rear; conical rear cavity, 1.07 inches long. F. A. Am. No. 57. Reported on March 28, 1870.
217	Hazard's musket powder, 70 grains, compressed from rear; conical rear cavity, .97 inch long. F. A. Am. No. 59. Reported on March 28, 1870.
218	Hazard's musket powder, 70 grains, compressed from both ends; rear cavity, 1.17 inches long. F. A. Am. No. 79. Reported on March 28, 1870.
219	Hazard's musket powder, 70 grains, compressed from both ends; rear cavity, 1.07 inches long. F. A. Am. No. 80. Reported on March 28, 1870.
220	Hazard's musket powder, 70 grains, compressed from both ends; rear cavity, .97 inch long. F. A. Am. No. 81. Reported on March 28, 1870.
221	Du Pont's rifle powder, 70 grains, compressed from rear; perforated, 1.17 inches long. F. A. Am. No. 82. Fired April 14, 1870.
222	Du Pont's rifle powder, 70 grains, compressed from rear; perforated, 1.12 inches long. F. A. Am. No. 83. Fired April 14, 1870.
223	Du Pont's rifle powder, 70 grains, compressed from rear; perforated, 1.07 inches long. F. A. Am. No. 84. Fired April 14, 1870.
224	Du Pont's rifle powder, 70 grains, compressed from rear; perforated, 1.02 inches long. F. A. Am. No. 85. Fired April 14, 1870.
225	Du Pont's rifle powder, 70 grains, compressed from rear; perforated, .97 inch long. F. A. Am. No. 86. Fired April 14, 1870.
226	Du Pont's rifle powder, 70 grains, compressed from rear; perforated, .92 inch long. F. A. Am. No. 101. Fired April 14, 1870.
227	Du Pont's rifle powder, 70 grains, compressed from rear; perforated, .87 inch long. F. A. Am. No. 102.
228	Hazard's F. F. G. powder, 70 grains, compressed in the case; .05 inch solid. F. A. Am. No. 87. Fired September 3, 1870.

SIXTH DRAWER—Continued.

MODIFICATION OF CHARGE—Continued.

No.	Description.
229	Hazard's F. F. G. powder, 70 grains, compressed in the case; .1 inch solid. F. A. Am. No. 88. Fired September 3, 1870.
230	Hazard's F. F. G. powder, 70 grains, compressed in the case; .15 inch solid. F. A. Am. No. 89. Fired September 3, 1870.
231	Hazard's F. F. G. powder, 70 grains, compressed in the case; .2 inch solid. F. A. Am. No. 90. Fired September 3, 1870.
232	Hazard's F. F. G. powder, 70 grains, compressed in the case; .25 inch solid. F. A. Am. No. 91. Fired September 3, 1870.
233	Hazard's F. F. G. powder, 70 grains, compressed in the case; .3 inch solid. F. A. Am. No. 92. Fired September 3, 1870.
234	Hazard's F. F. F. G. powder, 70 grains, compressed in the case; .05 inch solid. F. A. Am. No. 93. Fired September 3, 1870.
235	Hazard's F. F. F. G. powder, 70 grains, compressed in the case; .1 inch solid. F. A. Am. No. 94. Fired September 3, 1870.
236	Hazard's F. F. F. G. powder, 70 grains, compressed in the case; .15 inch solid. F. A. Am. No. 95. Fired September 3, 1870.
237	Hazard's F. F. F. G. powder, 70 grains, compressed in the case; .2 inch solid. F. A. Am. No. 96. Fired September 3, 1870.
238	Hazard's F. F. F. G. powder, 70 grains, compressed in the case; .25 inch solid. F. A. Am. No. 97. Fired September 3, 1870.
239	Hazard's F. F. F. G powder, 70 grains, compressed in the case; .3 inch solid. F. A. Am. No. 98. Fired September 3, 1870.
240	Sleeper's chlorate powder, 15-grain charge. F. A. Am. No. 107. Fired August 27, 1870.
241	Sleeper's chlorate powder, 20-grain charge. F. A. Am. No. 108. Fired August 27, 1870.
242	Sleeper's chlorate powder, 25-grain charge. F. A. Am. No. 109. Fired August 27, 1870.
243	Sleeper's chlorate powder, 30-grain charge. F. A. Am. No. 110. Fired August 27, 1870.
244	Gomez's iron gunpowder, 20-grain pills. Fired with different charges. F. A. Am. No. 302. Reported on July 10, 1873.

SEVENTH DRAWER.

MODIFICATION IN BULLET AND LUBRICANT.

[C. F. metallic, caliber ".50."]

No.	Description.
245	Bullet used in most bar anvil ammunition and up to 1868. F. A. Am. No. 58.
246	Experimental bullet with cannelures deepened to .04 inch to hold more lubricant, 1867. F. A. Ball No. 59.
247	Experimental bullet with cannelures deepened to .045 inch to hold more lubricant, 1867. F. A. Ball No. 60.
248	Bullet determined by Lieutenant Stockton's experiments and used in service from March, 1868, to July, 1870. F. A. Am. No. 1.
249	Experimental, a disk of lubricant with wad under the bullet *added to* the usual lubrication in the cannelures. F. A. Am. No. 73.
250	Experimental, a disk of lubricant with wad under the bullet *substituted for* the usual lubrication in the cannelures. F. A. Am. No. 14.
251	Experimental front lubrication case, projecting on the front of bullet, space filled up with lubricant in addition to that in the cannelures. F. A. Am. No. 20. Ord. Mem. No. 14, plate lxi.
252	Experimental star patch of bank-note paper, covering the base and cylindrical surface of the bullet; lubricant in cannelures. F. A. Am. No. 2.
253	Experimental star patch of bank-note paper, covering the base and cylindrical surface of the bullet and inclosing a disk of lubricant on the base of the bullet in addition to that in the cannelures. F. A. Am. No. 3.
254	Experimental star patch of bank-note paper, covering the base and cylindrical surface of the bullet; a disk of lubricant in paper capsule applied to the base of the bullet *outside* of the patch. F. A. Am. No. 4.
255	Experimental wrapped patch of bank-note paper, covering the cylindrical portion of the bullet and folded down on the base lubrication in cannelures. F. A. Am. No. 5.
256	Experimental wrapped patch of bank-note paper, covering the cylindrical portion of the bullet and folded down on a disk of lubricant applied to the base in addition to that in the cannelures. F. A. Am. No. 6.
257	Experimental wrapped patch of bank-note paper, covering the cylindrical portion of the bullet and folded down on the base; a disk of lubricant on base outside of patch. F. A. Am. No. 7.
258	Experimental; the diameter of the bullet reduced by .005 inch. F. A. Am. No. 24.
259	Experimental; the bullet hardened by addition of one-twelfth tin. F. A. Am. No. 21.
260	Experimental bullet, smooth, with lubricant in disk on base; wrapped patch. F. A. Am. No. 12.
261	Experimental bullet, smooth ellipsoidal front, with lubricant in disk on base; wrapped patch. F. A. Am. No. 203.
262	Experimental bullet, smooth, hardened with one-twelfth tin, patched and lubricated with disk of wax and wads like the earlier Martini Henry. F. A. Am. No. 15.

SEVENTH DRAWER—Continued.

MODIFICATION IN BULLET AND LUBRICANT—Continued.

No.	Description
263	Experimental bullet, with two broad cannelures (Benêt) instead of three ordinary ones. F. A. Am. No. 61.
264	Experimental bullet, with two broad cannelures (Benêt) like last, but lightened 40 grains by cavity in base. F. A. Ball No. 62.
265	Experimental bullet, with two broad cannelures (Benêt), lengthened to 2½ calibers; weight preserved at 450 grains by cavity in base. F. A. Am. No. 18.
266	Experimental bullet, with two broad cannelures (Benêt) like last, but hardened with one-twelfth tin. F. A. Am. No. 19.
267	Experimental bullet, with two broad cannelures (Benêt), lengthened to 2¼ calibers; weight preserved at 450 grains by cavity in base. F. A. Am. No. 23.
268	Experimental bullet, with two broad cannelures (Benêt) like last, but hardened with one-twelfth tin. F. A. Am. No. 27.
269	Experimental bullet, with two broad cannelures (Benêt), lengthened to 2¼ calibers; diameter reduced by .01 inch; weight preserved at 450 grains by cavity in base. F. A. Am. No. 28.
270	Experimental bullet, with two broad cannelures (Benêt) like last, but hardened with one-twelfth tin. F. A. Am. No. 29.
271	Experimental sectional bullet (Farley); front of bullet doweled into rear; lubricant between sections. F. A. Am. No. 16.
272	Experiment sectional bullet (Farley); rear of bullet doweled in front; lubricant between sections. F. A. Am. No. 17.
273	Experimental bullet; a conoidal frustum on a reduced conical frustum, flushed with lubricant. F. A. Am. No. 25.
274	Experimental bullet; a conoidal frustum on a reduced conical frustum, 1.1 inches long, flushed with lubricant. F. A. Am. Nos. 104 and 105.
275	Experimental bullet; imitation of Swiss "Federal" bullet; weight same as service lubrication in cannelures. F. A. Am. No. 26.
276	Service bullet resembling that of service ammunition, but diameter in front of front cannelure made equal to the general diameter, the reduction to be effected by the crimping of the case. Used in service ammunition from July 21, 1870. F. A. Am. No. 111.
277	Experimental, Robert's bullet; blunt ellipsoidal front, broad shallow cannelure, and cavity in the base; lubrication in cannelure. F. A. Am. No. 66.
278	Experimental, Dimmick's bullet No. 1; frustum of a conoid on frustum of a cone. F. A. Am. No. 126.
279	Experimental, Dimmick's bullet No. 2; frustum of a cone on a cylinder; two cannelures. F. A. Am. Nos. 134 and 135.
280	Experimental, Dimmick's bullet No. 3; frustum of cone on a cylinder; two cannelures; shallow-dished cavity in base. F. A. Am. No. 138.
281	Experimental, Week's bullet No. 1; conoidal frustum on cylinder; three bearing rings; lubrication by greased patched wrapped. F. A. Am. No. 157.
282	Experimental, Week's bullet No. 2; conoidal frustum on cylinder; two bearing rings; lubrication by circular greased patch. F. A. Am. No. 158.
283	Experimental, Week's bullet; smooth conoidal frustum on cylinder; lubrication by circular greased patch. F. A. Am. No. 160.
284	Experimental carbine, reduced from rifle musket, 450 grains to 430 grains, by conical cavity in base. F. A. Am. No. 177.
285	Experimental carbine, reduced from rifle musket, 450 grains to 415 grains, by conical cavity in base. Fired with various charges. F. A. Am. Nos. 178, 181, and 186.
286	Experimental carbine, reduced from rifle musket, 450 grains to 400 grains, by conical cavity in base. Fired with various charges. F. A. Am. Nos. 179, 182, and 187.
287	Experimental carbine, reduced from rifle musket, 450 grains to 385 grains, by conical cavity in base. Fired with various charges. F. A. Am. Nos. 180, 183, and 188.
288	Experimental carbine, reduced from rifle musket, 450 grains to 415 grains, by making the front ellipsoidal. Fired with two different charges. F. A. Am. Nos. 190 and 192.
289	Experimental carbine, reduced from rifle musket, 450 grains to 430 grains, by making the front ellipsoidal. Fired with two different charges. F. A. Am. Nos. 189 and 191. The latter with 55-grain charge was adopted as service carbine cartridge, 1872.
290	Experimental, Hubbell's adaptation of the Prussian needle-gun bullet and sabot to metallic case. Fired with slight modifications in three forms. F. A. Am. Nos. 244, 245, and 246.
291	Experimental, gas-check bullet; substantially like service .50 caliber, but made to lap outside the mouth of case. F. A. Am. No. 287.
292 to 310	Vacant.

EIGHTH DRAWER.

DISK AND BAR ANVILS.

No.	Description.
311	Center swell base copper disk anvil; two vents; short case; charge, 40 grains; bullet, 450 grains. Frankford Arsenal, 1865; experimental. Ord. Mem. No. 14, plate v.
312	Iron disk anvil, chamfered and crimped into flange; slot vent. Springfield 1867.
313	Broad bar anvil, iron chamfered and crimped into flange; slot vent. Springfield, 1867.
314	Martin straight bar re-enforced; tinned iron with re-enforce copper cup held in by indents. Springfield, 1867. Ord. Mem. No. 14, plate xiii.
315	Martin straight bar; tinned iron held by indents, as made for service at Frankford Arsenal, from October, 1866, to March, 1868. F. A. Am. No. 133. Ord. Mem. No. 14, plate x.
316	Copper bar anvil; chamfered ends held by re-entrant fold. Springfield. 1870. Record No. 115.
317	Copper disk anvil, plain square edge, held in by indents. Frankford Arsenal, August, 1871. Ord. Mem. No. 14, plate xxxi A.
318	Copper disk anvil in re-enforcing cup, both held by indents. Frankford Arsenal, February, 1872. Ord. Mem. No. 14, plate xl. Record No. —.
319	Copper disk anvil; chamfered, held in by re-entrant fold. Frankford Arsenal. October, 1871. Ord. Mem. No. 14, plate xxxi D. Record No. 199.
320	Copper disk anvil, expanding, held in by indents; has re-entrant fold underneath. Ord. Mem. No. 14, plate xxxi C. Frankford Arsenal, 1871. Record No. 197.
321	Copper disk anvil, expanding, held in by knurl all around; has fold underneath. Frankford Arsenal, October, 1871. Record No. 201.
322	Copper disk anvil, corrugated, held in by knurl all around; case with corrugated base. Frankford Arsenal, 1871. Ord. Mem. No. 14, plate xxxii. Record No. —.
323	Covered base anvil, primed outside of base, priming covered by a flat cap embracing flange. Frankford Arsenal, February, 1872. Record No. —.
324	Needle or disk and bolt anvil, priming; in case of bullet; disk held in by flange and supporting axial bolt extending almost to priming; bolt pointed like a firing-pin. Frankford Arsenal, for Lieutenant Corliss. Reported on February 16, 1871. Ord. Mem. No. 14, plate xxxiii. Record No. 136.
325	Needle or disk and bolt anvil, like last, but bolt squared in front like a winding arbor. Frankford Arsenal. Record No. 137.
326	Martin rocket short-bar anvil, held in by re-entrant folded pocket; flange re-enforced by ring inside (original Martin). Springfield. F. A. Am. No. 202. Ord. Mem. No. 14, plate xliii.
327	Martin pocket, without re-enforcing ring, anvil tin or copper. Springfield Armory, 1869. F. A. Am. No. 118. Ord. Mem. No. 14, plate xx.
328	Martin pocket in brass. Springfield, 1869. F. A. Am. No. 117.
329	Martin pocket with re-entrant fold above flange. Springfield, 1870. F. A. Am. No. 113.
330	Martin pocket with re-entrant fold and double, and double indented anvil made for service at Frankford Arsenal, November and December, 1871. F. A. Am. No. 176. Ord. Mem. No. 14, plate xxii.
331	Martin pocket, re-enforced with solder in flange. Frankford Arsenal, 1872. Record No. —.
332	Martin pocket, closed down without anvil. Frankford arsenal, 1873. Record No. —.

CAP PRIMED CASES.

333	Vacant.
334	Vacant.
335	Benét narrow pocket saddle anvil in small cap, short case; bullet No. 57. Frankford Arsenal, 1866.
336	Benét wide-pocket saddle anvil in large cap, short case; bullet No. 57. Frankford Arsenal, 1866.
337	Solid nipple head; iron nipple in pocket in solid brass base of case; short case. Frankford Arsenal, 1865, record No. —.
338	Crispin foil and paper; pocket pressed in brass cup attached to base of foil and paper case; different thicknesses of foil tried. Frankford Arsenal, 1867. Ord. Mem. No. 14, plate xvii.
339	Laidley arch anvil; inside cap iron anvil reaching to bullet. Springfield, 1865. Ord. Mem. No. 14, plate vii.
340	Laidley capped bar; inside cap on an arched bar held in by indents. Springfield, 1866. Ord. Mem. No. 14, plate viii.
341	Star cap-receiver; inside cap and anvil, contained in a star-shaped pocketed receiving plate. Frankford Arsenal, 1866. Ord. Mem. No. 14, plate vi.
342	Cup-cap receiver; inside cap and anvil, contained in a pocket of re-enforcing cup at bottom of case. Frankford Arsenal, February, 1872. Ord. Mem. No. 14, plate xlix.
343	Re-enforced pocket case; re enforcing ring clinched in by pressing back the pocket outside cap spear-head anvil. Frankford Arsenal, 1872. Ord. Mem. No. 14, plate xxxviii A; record No. —.
344	Plate flanged; brass base plate, held on by a separate clinched pocket; ou side cap and spear-head anvil. Frankford Arsenal, 1872. Ord. Mem. No. 14, plate xlii.
345	Plate flanged; brass base plate, held on by a solid inside pocket; clinched outside; outside cap and spear-head anvil. Frankford Arsenal, January, 1872. Record No. —.
346	Wrapped metal; soldered into pocketed base cup; outside cap and spear-head anvil. Frankford Arsenal, January, 1872. Ord. Mem. No. 14, plate l.
347	Front ignition; wrapped metal, soldered into base cap, with pocket reaching nearly to bullet; outside cap and bolt anvil. Frankford Arsenal, 1872. Record No. 292.
348	Front ignition case, pocketed, for cap and spear-head anvil; the pocket prolonged in a small tube nearly to the bullet. Frankford Arsenal, 1872. Ord. Mem. No. 14, plate xxxiv.
349	Treadwell cube anvil; case re-enforced with inside ring, pocketed for outside cap containing cubical anvil. Frankford Arsenal, 1872. Ord. Mem. No. 14, plate xxxviii B.
350	Treadwell cube anvil case, re-enforced, with solder pocketed for outside cap, containing cubical anvil.

EIGHTH DRAWER—Continued.

CAP PRIMED CASES—Continued.

No.	Description.
351	Treadwell spherical anvil case, re-enforced, with solder in flange, pocketed for outside cap containing spherical anvil. Frankford Arsenal, 1872. Ord. Mem. No. 14, plate xliv.
352	Cast base, wrapped metal, with soft metal base, cast on, pocketed for outside cap and circular anvil. Frankford Arsenal, February, 1872. Ord. Mem. No. 14, plate lii.
353	Berdan base; base of case pocketed and re-enforced in Berdan style, with his return pocket, anvil, and caps. Frankford Arsenal, 1872. Record No. —.
354	Berdan anvil, wrapped metal; base cup pocketed, with Berdan return anvil, re-enforcing ring replaced by the wrapped metal and solder. Frankford Arsenal, 1872. Record No. 251.

CUP ANVILS.

355	Tinned cup anvil; straight case; tinned cup held in by the crimps or indents. Frankford Arsenal. Service from March, 1868, to September, 1869. F. A. Am. No. 1.
356	Tinned cup anvil; cylindrical-throated case; tinned cup held in by two crimps or indents. Frankford Arsenal. Service from September, 1869, to August, 1870. F. A. Am. No. 11. Ord. Mem. No. 14, plate xiv.
357	Side vent cup anvil; cup without vent holes, but with sides; flutes leading from priming held in by indents. Frankford Arsenal, 1868.
358	Copper cup anvil; copper cup substituted for tin, held in by two crimps or indents. Frankford Arsenal. Service from August, 1870, to November, 1871. Record No. 112.
358 *bis*	Cups for last of various vents and material; experimental. Frankford Arsenal, December, 1870 Record No. 127.
359	Corrugated base copper cup anvil; annular depression near edge of base. Springfield and Frankford, October, 1870. F. A. Am. No. 118½. Ord. Mem. No. 14, plate xxvii.
360	Double crimped copper cup anvil; crimp in front of cup extended all around. Frankford Arsenal, October, 1870. Record No. 119.
361	Corrugated base and double crimp, combining the peculiarities of the last two. Frankford Arsenal, October, 1870. Record No. 170.
362	Corrugated base with knurl instead of crimp in front of cup. Springfield and Frankford, November, 1870. Record No. 121.
363	Reduced case copper cup anvil; held in by reducing the diameter of the whole case in front of it by .02 inch. Frankford Arsenal, December, 1870. F. A. Am. No. 128. Ord. Mem. No. 14, plate xxix.
364	Reduced case copper cup anvil; held in by reducing the diameter of the whole case in front of it by .01 inch. Frankford Arsenal, January, 1871. Record No. 132.
365	Shallow cup; copper cup reduced in depth by .05 inch. Frankford Arsenal. Service from December, 1871. Record No. 184.
366	Solder re-enforce to copper cup anvil; solder run into flange; annular corrugation in base to make a trough for it. Frankford Arsenal, January, 1872. Record No. —.
367	Martin re-entrant fold, with copper cup anvil, and their re-enforcing cup between anvil and case. Springfield, January, 1872. Record No. 200.
368	Solid head copper cup anvil. Frankford Arsenal, 1868. Record No. 170. Ord. Mem. No. 14, plate lv.
369	Double case copper cup anvil, reaching to base of bullet. Frankford Arsenal, January, 1872. Ord. Mem. No. 14, plate xxx.
370	Cone cup anvil; re-enforcing ring inside of flange. Frankford Arsenal, January, 1872. Ord. Mem. No. 14, plate xxxvi A. Record No. —.
371	Cone cup anvil; re-enforcing cup and perforated base. Frankford Arsenal, January, 1872. Ord. Mem. No. 14, plate xxxvii.
372	Outside cup case itself the anvil; priming inside covered by a flanged cup. Frankford Arsenal, 1872. Record No. —.
373	Concave base copper cup held against a concave base; base to yield in firing. Frankford Arsenal, June, 1872. Ord. Mem. No. 14, plate xxviii.
374	Treadwell open base; double cup as made for ".45 caliber. Frankford Arsenal, 1873. Record No. 301.
375	Moore's collar flange; plain unflanged case inclosed in a flanged collar. Frankford Arsenal, 1874. Record No. 349.
376	Solid head Berdan teat anvil; priming for ".45 caliber, rifle; brass case. Made at Frankford Arsenal, July, 1874. Record No. 346.
377	Vacant.
378	Remington B. L. pistol; cup anvil; caliber ".50.
379	Remington B. L. pistol, Martin pocket; caliber ".50.
380	Colt's revolver, Martin pocket; caliber ".44.
381	Smith & Wesson revolver, Martin pocket; caliber ".44.
382	Colt's revolver, Franklin's front extraction cup anvil; caliber ".44. Frankford Arsenal, November, 1868. Ord. Mem. No. 14, plate xviii.
383	Colt's Navy, cup anvil.

NINTH DRAWER.

MODIFICATIONS IN CALIBER.—REDUCTIONS.

[".45 caliber."]

No.	Description.
384	Bottle-shaped case, 80-grain charge, 400-grain bullet, cannelured; length of cartridge, 2.6 inches. F. A. Am. No. 148. Reported on January 6, 1872.
385	Bottle-shaped case, 75-grain charge, 400-grain bullet, cannelured; length of cartridge, 2.5 inches. F. A. Am. No. 149. Reported on January 6, 1872.
386	Bottle-shaped case, 70-grain charge, 400-grain bullet, cannelured; length of cartridge, 2.4 inches F. A. Am. No. 150. Reported on January 6, 1872.
387	Bottle-shaped case, 80-grain charge, 420-grain bullet, cannelured; length of cartridge, 2.6 inches. F. A. Am. No. 151. Reported on January 6, 1872.
388	Bottle-shaped case, 75-grain charge, 420-grain bullet, cannelured; length of cartridge, 2.5 inches. F. A. Am. No. 152. Reported on January 6, 1872.
389	Bottle-shaped case, 70-grain charge, 420-grain bullet, cannelured; length of cartridge, 2.4 inches. F. A. Am. No. 153. Reported on January 6, 1872.
390	Bottle-shaped case, 80-grain charge 440-grain bullet, cannelured; length ot cartridge, 2.6 inches. F. A. Am. No. 154. Reported on January 6, 1872.
391	Bottle-shaped case, 75-grain charge, 440-grain bullet, cannelured; length of cartridge, 2.5 inches. F. A. Am. No. 155. Reported on January 6 and June 21, 1872.
392	Bottle-shaped case, 70-grain charge, 440-grain bullet, cannelured; length of cartridge, 2.4 inches. F. A. Am. No. 156. Reported on January 6, 1872.
393	Bottle-shaped case, 80-grain charge, 425-grain bullet, smooth-patched and dipped; inserted .4 inch. F. A. Am. No. 204.
394	Bottle-shaped case, 75-grain charge, 425-grain bullet, smooth-patched and dipped; inserted .5 inch. F. A. Am. No. 205. Reported on June 21, 1872.
395	Martini-Henry imitation, Martin base, with re-enforce ring, hardened bullet; patch and wad to resemble Henry ammunition made at Springfield Armory, and reported on from there.
396	Sectional bullet, hardened front; lead base to drive up the Schenkle sabot. F. A. Am. No. 289. Failed entirely.
397	Bottle-shaped case, short lap, 75-grain charge, 440-grain bullet, cannelured; inserted .2 inch. Lubrication base wad and dipped. F. A. Am. No. 217. Reported on June 21, 1872. No. 26 of report of Small-Arms Caliber Board.
398	Bottle-shaped case, short lap, 75-grain charge, 425-grain bullet, smooth; inserted .15 inch; lubrication base wad and dipped. F. A. Am. No. 218. Reported on June 21, 1872. No. 28 of report of Small-Arms Caliber Board.
399	Bottle-shaped case, short lap, 75-grain charge, long Laidley bullet, 485 grains, cannelured; inserted .15 inch; lubrication base wad and dipped. F. A. Am. No. 219. No. 29 of report of Small-Arms Caliber Board.
400	Bottle-shaped case, long lap, same as last, but lap of case on bullet increased from .15 inch to .45 inch. F. A. Am. No. 220. No. 30 of report of Small-Arms Caliber Board.
401	Vacant.
402	Vacant.
403	Straight case, charges 60, 70, 75, and 80 grains; bullet, 400 grains; four cannelures, one exposed; length, 2.78 inches; same for all charges. F. A. Am. Nos. 258 to 262, inclusive. Made at Springfield Armory for Small-Arms Caliber Board, and represents Nos. 39 to 43, inclusive, of its report.
404	Straight case, charge 70 grains; bullet, 400 grains; four cannelures, all covered; length, 2.68 inches. F. A. Am. No. 266. Made at Springfield Armory for Small-Arms Caliber Board, and No. 47 of its report.
405	Straight case; same as last, but case shortened .18 inch, making length 2.5 inches. F. A. Am. No. 269. No. 50 of Small-Arms Caliber Board report.
406	Straight case, hardened, 405 grain bullet, 70 grain dense musket powder; lubricant in cannelures, case 2.1 inches long lapping, .61 inch on the bullet made at Springfield, and recommended by Small-Arms Caliber Board, No. 58 of its report. F. A. Am. No. 280.
407	Straight case; substantially like last, but made by machinery at Frankford Arsenal, after adoption by War Department. F. A. Am. No. 294.

[".42 caliber."]

408	Bottle-shaped case, 80-grain charge, 350-grain bullet, cannelured; length of cartridge 2.6 inches. F. A. Am. No. 139. Reported on April 22, 1871, and January 6, 1872.
409	Bottle-shaped case, 75-grain charge, 350-grain bullet, cannelured; length of cartridge 2.5 inches. F. A. Am. No. 140. Reported on January 6, 1872.
410	Bottle-shaped case, 70-grain charge, 350-grain bullet, cannelured; length of cartridge 2.4 inches. F. A. Am. No. 141. Reported on April 22, 1871, and January 6, 1872.
411	Bottle-shaped case, 80-grain charge, 370-grain bullet, cannelured; length of cartridge 2.6 inches. F. A. Am. No. 142. Reported on April 22, 1871, and January 6, 1872.
412	Bottle-shaped case, 75-grain charge, 370-grain bullet, cannelured; length of cartridge 2.5 inches. F. A. Am. No. 143. Reported on April 22, 1871, and January 6, 1872.
413	Bottle-shaped case, 70-grain charge, 370-grain bullet, cannelured; length of cartridge 2.4 inches. F. A. Am. No. 144. Reported on April 22, 1871, and January 6, 1872.
414	Bottle-shaped case, 80-grain charge, 385-grain bullet, cannelured; length of cartridge 2.6 inches. F. A. Am. No. 145. Reported on April 22, 1871, and January 6, 1872.
415	Bottled-shaped case, 75-grain charge, 385-grain bullet, cannelured; length of cartridge, 2.5 inches F. A. Am. No. 146. Reported on April 22, 1871, and January 6, 1872.
416	Bottle-shaped case, 70-grain charge, 385-grain bullet, cannelured; length of cartridge, 2.4 inches. F. A. Am. No. 147. Reported on April 22, 1871, and January 6, 1872.
417	Bottle-shaped case, 80-grain charge, 350-grain bullet, smooth patched; inserted .4 inch. Lubrication base disk and dipped. F. A. Am. No. 206. Tested March and April, 1872.

NINTH DRAWER—Continued.

MODIFICATIONS IN CALIBER.—REDUCTIONS—Continued.

[".42 caliber."]

No.	Description.
418	Bottle-shaped case, 75-grain charge, 350-grain bullet, smooth patched; inserted .5 inch. Lubrication base disk and dipped. F. A. Am. No. 207. Tested March and April, 1872.
419	Bottle-shaped case, 80-grain charge, 370-grain bullet, smooth patched; inserted .4 inch. Lubrication base disk and dipped. F. A. Am. No. 209. Tested March and April, 1872.
420	Bottle-shaped case, 75-grain charge, 370-grain bullet, smooth patched; inserted .5 inch. Lubrication base disk and dipped. F. A. Am. No. 210. Tested March and April, 1872.
421	Bottle-shaped case, 75-grain charge, ratchet bullet, 373 grains. Lubricated in ratchet cannelures. F. A. Am. No. 169. Tested June, 1871.
422 to 427	Vacant.
428	Straight case, 70, 75, and 80-grain charges, 370-grain bullet, with four shallow cannelures; one exposed; same exterior (3.1 inches long) for all charges. F. A. Am. Nos. 239, 240, and 241. Made at Springfield Armory for Small-Arms Caliber Board, and represents Nos. 20, 21, and 22 of its report.
429	Straight case, 60, 65, 70, 75, and 80-grain charges, 365-grain bullet, with four deep (.02 inch) cannelures; one exposed; same exterior (3.1 inches long) for all charges. F. A. Am. Nos. 242, 252, 253, 254, 255, and 257. Made at Springfield Armory for Small-Arms Caliber Board, and represents Nos. 23, 33, 34, 35, 36, and 38 of its report.
430	Straight case, 65-grain charge, 365-grain bullet, with four deep cannelures, all covered by case. Length, 3 inches. F. A. Am. No. 267. Made at Springfield Armory for Small-Arms Caliber Board, and is No. 48 of its report.
431	Straight case, 65, 70, 75-grain charges, 365-grain bullet, four deep cannelures, all covered; case shortened. Total length, 2.8 inches; same for all charges. F. A. Am. Nos. 268, 278, and 279. Made at Springfield Armory for Small-Arms Caliber Board, and represents Nos. 49, 54, and 55 of its report.

[".40 caliber."]

432	Bottle-shaped case, 75-grain charge, 350-grain bullet; smooth patched; base disk of lubricant and thick felt wad; parts made at Springfield Armory. F. A. Am. No. 171. Reported on October 28, 1871, on Form, Class 6.
433	Bottle-shaped case, 80-grain charge, 350-grain bullet; smooth patched; base disk of laubricantand thin felt wad, to increase powder space. Parts made at Springfield Armory. F. A. Am. No. 172. Reported on October 28, 1871, on Form, Class 6.
434	Bottle-shaped case, 75-grain charge, like No. 432, except that the case is re-enforced by a ring inside the flange. Parts made at Springfield Armory. F. A. Am. No. 193. Reported on January 4, 1872.
435	Bottle-shaped case, 80-grain charge, otherwise like last. F. A. Am. No. 194. Reported on January 4, 1872.
436	Vacant.
437	Vacant.
438	Vacant.
439	Straight case, charges 80, 75, 70, and 65 grains, 350-grain bullet, smooth greased patch; total length (same for all charges), 3.28 inches. F. A. Am. Nos. 221 to 228, inclusive. Made at Springfield Armory for Small-Arms Caliber Board, and represents Nos. 2 to 9, inclusive, of its report.
440	Straight case, 80-grain charge, 400-grain bullet, with seven cannelures; lubrication in cannelures. F. A. Am. No. 229. Made at Springfield Armory for Small-Arms Caliber Board, and is No. 10 of its report.
441	Straight case, 75, 70, and 65-grain charges, 350-grain bullet, with four cannelures; lubrication in cannelures; length the same for all charges. F. A. Am. Nos. 230, 231, and 232. Made at Springfield Armory for Small-Arms Caliber Board, and represents Nos. 11, 12, and 13 of its report.
442	Straight case, 70, 65, and 60-grain charges, 350-grain bullet, with five shallow (.01 inch) cannelures; lubrication in cannelures; length the same for all charges. F. A. Am. Nos. 235, 236, and 237, and when dipped Nos. 233 and 234. Made at Springfield Armory for Small-Arms Caliber Board, and represents Nos. 14 to 18, inclusive, of its report.
443	Straight case, 65-grain charge, 340-grain bullet, with five deep (.02 inch) cannelures, three of which are covered by the case; lubrication in cannelures. F. A. Am. Nos. 238 and 263. Made at Springfield Armory for Small-Arms Caliber Board, and represents Nos. 19 and 44 of its report.
444	Straight case, like last, but bullet inserted until four cannelures are covered by case. For Small-Arms Caliber Board, and is No. 45 of its report.
445	Straight case, like last, but bullet inserted until all five of the cannelures are covered by the case, making the total length of cartridge 3 inches. F. A. Am. No. 265. Made at Springfield Armory for Small-Arms Caliber Board, and is No. 46 of its report.
446	Straight case, 70-grain charge, very light bullet (290 grains), smooth greased patch. F. A. Am. No. 243. Made at Springfield Armory for Small-Arms Caliber Board, and is No. 24 of its report.
447	Straight case, 65 and 70-grain charges, hardened bullet, 340 grains, one-twelfth tin, five deep cannelures, covered by case; length same for both charges; lubrication in cannelures. F. A. Am. Nos. 283, and 284. Made at Springfield Armory for Small-Arms Caliber Board, and represents Nos. 59 and 60 of its report.
448	Vacant.
449	Vacant.

TENTH DRAWER.

SERVICE AMMUNITION AND STAGES OF MANUFACTURE.

No.	Description.
450	".50 caliber musket, 70-grain charge, 450-grain bullet; case, 143 grains; shallow copper cup anvil as made for service from January, 1872, to December 29, 1873. Letter of Chief of Ordnance, stopping manufacture. F. A. Am. No. 184.
451	".50 caliber cadet musket, 45-grain charge, 385-grain bullet; case shortened to 1.33 inches; made originally for the short-chambered Remington navy carbine, model 1868. F. A. Am. No. 100. Reported on November 15, 1870, &c.
452	".50 caliber carbine, 55-grain charge, 430-grain bullet, with ellipsoidal front; adopted January, 1872. F. A. Am. 191. Reported on December 28, 1871.
453	".50 caliber pistol (Remington B. L.), 25-grain charge, 300-grain bullet; made for Army Remington B. L. pistol after July, 1871, and a nearly similar one for navy. F. A. Am. No. 168. Reported on June 12, 1871.
454	".50 caliber blank musket, charge 70 or 80 grains; case 1.5 inches long; closed with tar composition and later with shellac. F. A. Am. Nos. 22 and 334.
455	".50 caliber blank Gatling, charge 100 grains, case 2.25 inches long. Compressed and closed with varnish. F. A. Am. No. 335.
456	".45 caliber rifle, charge 70 grains; bullet, 405 grains, hardened. The cartridge adopted by Small-Arms Caliber Board as made at Frankford Arsenal, 1874. F. A. Am. No. 347.
457	".45 caliber carbine, charge 55 grains; bullet, 405 grains, hardened. Made at Frankford Arsenal from September, 1873. F. A. Am. No. 348. Reported on August 20, 1873.
458	".45 caliber pistol (Colt), charge 30 grains; bullet, 250 grains; made at Frankford Arsenal from September, 1873. F. A. Am. No. 320. Reported on September 15, 1873.
459	".45 caliber blank rifle and carbine.
460	".45 caliber revolver blank.
461	".44 caliber pistol (Smith & Wesson), charge 30 grains; bullet, 225 grains; made at Frankford Arsenal from August, 1871. F. A. Am. No. 165. Reported on July 13 and 14, 1871.
462	".44 caliber blank pistol (Smith & Wesson), charge 40 grains.
463	Musket powder for all small-arm cartridges. Light "Oriental" for ".50 caliber; dense "Hazard," &c., for ".45 caliber.
464	Lead bar for bullets of all cartridges except the ".45 caliber rifle and carbine.
465	Alloy bar for bullets: Tin, 1; lead, 16. For bullets of ".45 caliber.
466	Japan wax. Generally used for lubrication of bullets.
467	Bayberry wax, 8 parts; graphite, 1 part. Preferred for lubrication of bullets when bayberry wax obtainable.

No. 2. Board showing progressive stages in manufacture of the metallic ammunition, shot and canister for the 1-inch Gatling gun.

No. 3. Board showing progressive stages in manufacture of Springfield rifle cartridges; caliber, .50.

No. 4. Board showing progressive stages in manufacture of Springfield rifle cartridges; caliber, .45.

No. 5. Board showing progressive stages in manufacture of Lowell cartridges; caliber, .45.

No. 6. Board showing progressive stages in manufacture of the Rodman-Crispin wrapped brass cartridges.

No. 7. Board showing progressive stages in manufacture of Springfield revolver cartridges; caliber, .45.

No. 8. Two Boards showing various metallic cartridges. (*Vide* Ordnance Memoranda No. 14.)

No. 9. Five Formosan ammunition tubes.

Slips of bamboo containing very coarse powder and leaden slugs; captured from the Formosans by troops under General Saigo, Japanese army.

No. 10. Formosan powder flask.

Very small, containing fine-grained gunpowder used for priming flint-locks; captured from the Formosans by troops under General Saigo, Japanese army.

E.—Equipments and Accouterments.

No. 1. Minute-man, 1776. (Lay figure.)

Costume copied from statue of same name; armed with a flint-lock musket used at the battle of Bunker Hill by Jos. Burge; also provided with a powder horn. Uniform contributed by the Quartermaster Department. Musket, together with bayonet and cartridge-box, loaned by Mr. Burge, of New Haven, Conn.

No. 2. Rifleman, 1820. (Lay figure.)

This uniform was used in the war of 1812, when, with few exceptions, the troops were simply armed with the old flint-lock musket of the Revolutionary war and new arms of the same pattern modified as then made at the Springfield Armory. Very soon after the close of the war, however (in 1819), the Ordnance Department proceeded to arm the troops with a breech-loading arm, the Hall's flint-lock *breech-loading* rifle, some ten thousand of which were made and issued to the troops. Besides the importance of this move, as being the first attempt of any Government to arm its troops in quantities with breech-loading arms, these guns were further signalized as being made almost entirely with machinery and for being interchangeable in their parts. This feature, it may be observed, is of the utmost importance in the facility with which it permits repairs to be made in the field. A broken part can be instantly replaced by one exactly like the original. The old way was to make each part of the arm by itself, and to adapt it to the variations in form of its neighbors. All the parts belonging to any gun were marked with the number of that gun, and repairs or the dismemberment of a large number of guns at an arsenal, gave an infinite deal of trouble. The principle of the interchangeability of parts first generally adopted for muskets has spread and in this country is now a canon of the manufacture of all small machines made in quantity—sewing machines, steam-engines, printing presses, &c. (See Ordnance Notes 25, p. 137.) The cartridge-box with which this figure is supplied, though not strictly regulation, was used in the war of 1812.

No. 3. Infantry soldier, Mexican war.

This figure is armed with the percussion musket model 1842. These guns were used during this war, although the necessities of the service did not permit the complete extinction of the flint lock. The white cross-belts of the time are also shown.

No. 4. Infantry soldier, undress, 1858 to 1866.

This figure is clothed and equipped as prescribed during the closing scenes of the war of the rebellion. The musket is the Springfield muzzle-loading rifle musket, caliber, 58; accouterments to match.

No. 5. Cavalry soldier, undress, 1858 to 1868.

The cavalryman of the last part of the war of the rebellion. The continued efforts of the Ordnance Department to provide the cavalry with a breech-loading arm are here seen exemplified in the Spencer repeating rifle carbine, caliber, .52, firing seven shots. He has also a Colt's six-shooting revolver and a saber. A Blakeslee cartridge-box carries thirteen magazine tubes filled with cartridges ready for this magazine. The revolver ammunition is carried in the cap pouch. The carbine is slung across his shoulder on the carbine swivel.

No. 6. Cavalry accouterments and horse equipments.

These are presented upon a lay figure of a horseman mounted upon a carved wooden horse. The equipment comprises the following articles. (See Ordnance Memoranda No. 18): 1 saddle, complete, leather-covered, with carbine socket and strap; 1 curb

bridle; 1 halter; 1 watering bridle; 1 pair saddle bags with two ration bags inside; 1 blanket; surcingle; link; side line; nose bag; lariat and picket pin; horse brush; curry comb; spurs and straps; saber belt; 1 pouch for carbine cartridges; 1 pouch for pistol cartridges; 2 cartridge loops for carbine cartridges; 1 pistol holster; 1 saber knot; 1 carbine sling and swivel.

The following cavalry accouterments and horse equipments are furnished only on special requisition: Graduated felt saddle cloth; halter chain; sweat leathers; guidon socket; haversack for dismounted service.

No. 7. Pistol holster; new model.

The holster swivels on the Hoffman attachment, which is attached to a loop sliding on the waist-belt. The wide hood, necessary in the days of paper ammunition, is replaced by a narrow strap merely confining the pistol in place. (See Ordnance Memoranda No. 18)

No. 8. Light artillery accouterments and harness; 1876.

Represented upon a lay figure seated upon a model of a horse in carton-pierre, harnessed to the iron limber of the Benton carriage for the 3-inch rifle gun. Substantially the same as used during the war of the rebellion.

No. 9. Infantry soldier; full dress, 1876. (Lay figure.)

Armed with the Springfield rifle, caliber .45, and provided with the new (Palmer) equipments. The principal feature of this equipment consists in the compensating pad, from which many advantages are derived. (See Ordnance Memoranda No. 19 to No. 39.) The haversack contains a meat can which opens to form two dishes, in which the meat may be cooked as well as carried. There is also a knife, fork, and spoon. The canteen is covered with thick petersham cloth, which, being dipped in water, cools the contents of the canteen by the evaporation which ensues. The adjustable tongueless buckle (Chambers) on the canteen and haversack straps are worthy of attention. It is also provided with the McKeever cartridge-box, opening from the top on a joint and running along its under side. When shut the cartridges lie heads and points very compactly; when open they lie in two tiers, a bellows-like fold permitting the heads to project sufficiently for grasping. (See Ordnance Memoranda No. 19, page 44.) It also has the steel bayonet scabbard with Hoffman's attachment. It is not intended that the entire equipment, as illustrated in this figure, should be always worn; but that advantage should be taken of the facility with which the application of the equipments may be varied, either extended to carry a full supply of everything or limited to the most necessary articles. The arrangement of the blanket does away with the objectionable features due to carrying it across the shoulder as practiced in the war of the rebellion.

No. 10. Infantry soldier; undress, 1876. (Lay figure.)

This figure is intended to illustrate the Palmer equipment reduced to meet the necessities of field service. All but the essential parts are dispensed with. Instead of the ordinary bayonet this figure has the trowel bayonet. (See Report Chief of Ordnance, 1873, p. 53.) This is meant, as its name implies, for use either as a weapon or as an intrenching tool, the rarity of its use as a weapon permitting certain of its advantages as such to be sacrificed to its efficiency as a spade. One edge is sharpened for use as a hatchet. The plug in the handle is removed before fixing the bayonet on the gun. The impossibility of stacking arms with this bayonet led to the invention of the stacking swivel shown on the upper band of the rifle. (See pamphlet describing Springfield rifle.) This stacking swivel has since been adopted for all rifles and carbines in the military service. The figure is also provided with the Metcalfe cartridge-block for which the rifle is adapted. (See Ordnance Memoranda No. 19, pp. 46 and 60.) This is now on trial in the field. The blocks are to be worn in the

steel clasps upon the belt until needed for action, when they are to be taken off as needed and fastened to the side of the gun. This position is favorable for great rapidity of fire. The blocks are thrown away when exhausted. When used with the clasps they dispense with the cartridge-box, and distribute the reduced weight around the waist. Single cartridges may be picked from them in this position if required.

No. 11. Clothing bag.

This contains the soldier's clothing and takes the place of the old knapsack. The pocket is for small articles. The rubber flap is being superseded by a layer of rubber between two folds of cloth. (See Ordnance Memoranda No. 19.)

No. 12. Intrenching tool and scabbard. Issued for competitive trial with the trowel bayonet.

This tool is intended to offer all the advantages which the trowel bayonet affords as an intrenching tool, without involving the question of the merit of the present triangular bayonet, which is still retained. The split ring on the scabbard allows it to be fastened to any part of the equipment at pleasure. The scabbard is made of corrugated tin, covered with leather as a protection to the clothing from rust.

No. 13. Combined intrenching spade and hatchet.

One edge of the light spade is sharpened for use as a hatchet. It is provided with a leather socket for transportation on the person. (Private contribution.)

No. 14. Case from Watervliet Arsenal, showing component parts of harness and equipments in various stages of manufacture, viz:

1. Trace toggles:
   - Punched.
   - Dropped.
2. Double link:
   - Punch.
   - Dropped.
3. Tug links: Dropped.
4. Ear for iron tar and sponge bucket: Dropped.
5. Hame joint loop.
   - Dropped.
   - Finished.
6. Mouth-piece (bit):
   - Forged.
   - Finished (three samples).
7. Branch (Shoemaker bit):
   - Dropped.
   - Trimmed.
   - Finished.
8. Foot staple: Dropped.
9. Snap-hooks:
   - 1. Spring and tie piece.
   - 2. Wire belt to form body.
   - 3. Spring in place ready to assemble (round edge.)
   - 4. Assembled and finished (1 round edge, 1 oblong edge).
10. Vent cover (new pattern):
    - 1. Disk punched.
    - 2. Leather washer.
    - 3. Stem split at lower end and spread to form friction spring.
    - 4. Vent cover assembled.

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11. Oil can: To the screw top are attached two bowed wire springs, meeting at the other end, by which the oil is taken out in drops.
12. Spring catch, for compartments in field wagons; two specimens, showing both sides. A standing edge of the same size as that in the bolt knob receives the hasp of a padlock when it is desired to secure the compartment.

No. 15. Case showing specimens of brass work upon cavalry and infantry accouterments.

CAVALRY EQUIPMENTS.

(*Ordnance Memoranda No.* 18).

1. Front slide loop and hook, saber hook.
2. Saber sling buttons.
3. Saber-belt plate.
4. Regulating belt hook.
5. Slide loop, rear (saber belt).
6. Saber sling hooks (2).
7. Holster swivel and stop washer.
8. Washer for holster swivel.
9. Screw top of oil can.
10. Rein buckles, brass, 1¼ inch (2).
11. Curb strap buckles, brass, 1½ inch (2).
12. Throat lash buckles, brass, 1½ inch (2).
13. Check piece buckles, brass, 1¼ inch (2 each).
14. United States ornaments, ends of mouth-piece.
15. Brass rosettes browband (2).
16. Saddle rings and staples (4).
17. Foot staples (6).

The parts of the buckles, snaps, &c., are machine-made and interchangeable. They are assembled automatically by machine.

INFANTRY EQUIPMENTS.

Ordnance Memoranda No. 19.

a. Belt-plate and regulating hook, small.
b. Same, large.
c. Friction buckle (1 canteen, 1 haversack).
d. Bayonet frog, swivel, with stop plate and washer (Hoffman).
e. Bayonet-scabbard frog (Hoffman) complete; separated.
f. Canteen, cork, chain, and ring.
g. Swivel; stop plate and washer; trowel-bayonet frog.
h. Hook for attaching clothing bag or haversack to shoulder strap.
i. Swivel rod for (McKeever) cartridge-box.
j. Clamps (2) button and button washer.
k. Tip for trowel-bayonet scabbard.
l. Split ring for intrenching-tool scabbard.
m. Foot staple for intrenching-tool scabbard.
n. Mouth-piece for intrenching-tool scabbard.
o. Wire buckles, 2 sizes (12).
p. Square roller ring (2).
q. D roller ring, 2 sizes (2).

No. 16. Stuart's saber sling and belt.

The two branches of the saber sling are united in a brass spring hook, which fastens into a ring riveted to the waist belt. The advantage of this is the facility with which

the entire saber and its fastenings can be removed, leaving the belt upon the person with the revolver, cartridge-boxes, &c. The saber can then be hooked to the saddle in fighting on foot, &c. The transverse head of the snap-lever is made very long, both to facilitate unhooking and also to prevent twisting of the slings.

No. 17. Cavalry equipments. Ordnance Memoranda No. 13.

The main feature of this consists of the shoulder braces for supporting the weight upon the belt. The carbine sling, adjustable on the same plan as the ordinary gun sling, is connected to one of these braces. The ammunition is carried in the Dyer (General A. B. Dyer, late Chief of Ordnance,) pouch, which is lined with sheep-skin. The pistol holster has a leather pipe for the cleaning rod. The discomfort and inconvenience attending the use of these shoulder belts led to their abandonment and the adoption of the equipment prescribed in Ordnance Memoranda No. 18.

No. 18. Three curb bits, 1863.

Showing various degrees of severity. The bit with the ring is the most severe, its pattern being borrowed from the Mexicans.

No. 19. Two curb bits.

Present pattern of different degrees of severity. Pattern designed by Captain Shoemaker, O. S. K. The upper eyes of the branches are enlarged, forming an arc of a circle 3 inches in diameter struck from the end of the mouth-piece. When the bit is pulled the loop in the check-piece slides easily through these. The strain is thus applied directly to the arch of the mouth-piece, instead of a part of it being applied, as in former patterns, in merely stretching the check-piece, and bringing a strain upon the top of the head. The curb strap is fastened to the eye in the small cross-bar. The bit is also very light.

No. 20. Watering bit.

The toggles at the end of the bars are passed through the check rings in the halter, in riding the horse to water. Together with a separate rein it forms the watering bridle.

No. 21. Artillery haversack.

Used in carrying ammunition from the limber to the piece in light artillery, and to hold divers small implements in the service of heavy ordnance.

No. 22. Tube pouch.

Part of the gunners' equipments; contains the friction tubes and lanyard used in firing artillery.

No. 23. Artillery saddle and valise.

This is carried on the off-horse of an artillery team. The valise contains the driver's clothing. The saddle may be devoted to its ordinary use if necessary.

No. 24 (A). Lieut. C. L. Best's cartridge-box.

The bottom of the box is open and provided with four longitudinal tin ledges, so spaced that two rows of cartridges may hang between them by their rims. The bottom is provisionally closed by a leather flap, upon which the cartridges rest on their points. This flap is hinged so that it can be opened in sections, allowing only part of the cartridges to fall through at a time. When wanted they are slipped along the ledge, one by one, until the open end of the ledge is reached. Space is left above these cartridges for a reserve supply.

No. 25 (B). Colonel Robert's alteration of muzzle-loading cartridge-box, caliber, .58.

The box is cut in half horizontally, the sections being hinged together on the outer side. When the upper tier of twenty-five cartridges is exhausted the section is turned over outward and the lower section is exposed. The cartridges stand on their points on wooden partitions, their upper ends being supported by leather diaph ragms, through which they pass. The two sections are united by a strap which keeps the upper one from opening accidentally.

No. 26 (C). Lieut. J. G. Butler's cartridge-box.

A pouch lined with sheep-skin to be worn upon the belt, holding about twenty-five cartridges. There is an intermediate flap between the body of the pouch and the main exterior flap.

No. 27 (D). Col. S. Crispin's cartridge-box.

Meant to hold two paper-packing boxes as made at the arsenal, holding twenty cartridges each. When the upper box is exhausted it is to be thrown away and the lower box used. The small pockets are for implements.

No. 28 (E). General A. B. Dyer's cartridge-box.

A pouch lined with sheep-skin, designed to carry about sixty cartridges, caliber .50, when full. The sheep-skin protects the cartridges from injury, and keeps them from falling out without interfering with their ready extraction by hand. The small pocket is for revolver cartridges. The pouch is supported by a shoulder belt, which also serves as a carbine sling.

No. 29 (F). Lieut. J. G. Butler's cartridge-box.

A wooden block, curved to fit the body, is contained in a leather box, the lid of which is lined with sheep-skin. The block contains nineteen cartridges. The box is provided with loops for the waist belt. In another variety of this box the wooden block is replaced by two perforated diaphragms of tin, corrugated for stiffness.

No. 30 (H). Captain Clifford's vest, as modified at Watervliet Arsenal. (Right and left.)

Consists of a flat piece of leather about 8 inches square. Upon its face are sewed thirty leather loops for holding the cartridges. These are uncovered. One of these was to be worn on each side of the chest, being supported as described in M.

No. 31. (K.)—Tileston cartridge-box; caliber .50, as modified at Watervliet arsenal, leather loop.

Consists essentially of a flap of leather 8 by 12 inches, the lower third of which is folded up to form the bottom ends and side of the cartridge-box. When folded, it contains inside two rows of 10 leather loops, the inner row being slightly above the outer row. The cartridges in the inner row stand with the heads up; those in the outer row with the heads down. Outside of all is a third row, in which the cartridges stand with the heads up. This row having been exhausted, the ends are unbuttoned and the box unfolded; this brings the two inside rows into use. These are now one above the other, the heads of the cartridges in both being up.

No. 32. (L.)—Cartridge-box proposed by Saint Louis Board.

A pouch lined with sheep-skin and worn upon the belt without intermediate flap. It holds about twenty-five cartridges, and is fastened by a turn-buckle.

No. 33. (M.)—General Hagner's cartridge-box, right and left.

Consists of a stiff piece of leather 8 by 6 inches, on the front of which are sewed two rows of ten leather loops each. The cartridges which they contain are protected from dust by a leather flap and by a bottom piece sewed to two end pieces. The box is carried by a strap, one end of which is fastened to the back piece, and the other end, passing over the shoulder, buckles into a Λ-shaped swivel-brace attached at each end of the box. When used the flap is buttoned to the stud above it.

No. 34. (N.)—Tileston's pattern cartridge-box lined with waxed ticking, loops of waxed webbing.

Same as K, except that the loops, instead of being made of leather, are linen webbing on a backing of the same. This was adopted on account of the corrosive influence of the leather loops upon the metal of the cartridge case.

No. 35. McKeever cartridge-box; caliber .45; open.

Now on trial in the United States Army. See Ordnance Memoranda No. 19; also description in this catalogue of equipment of the United States infantry soldier of the present day.

No. 36. Metcalfe cartridge-block and carrier; caliber .45.

See description with lay figure, representing United States soldier, 1876, in marching order; also, Ordnance Memoranda No. 19.

The block is intended to be fastened to the side of the gun for rapid firing. The brass hook on the carrier holds the block firmly, even if drawn forcibly away from the person, against which it is held by the leather loop on its back. The groove in the back of the block steadies it in the carrier.

No. 37. Movable cartridge loops; caliber .45.

Twenty leather loops are sewed on both sides of a central strap 7 by 2 feet, to which are also fastened three belt loops. This is meant to secure the advantages of the scouting belt or loop belt so generally used on the frontier, without interfering with the use of the waist belt for other purposes, when the loops are not required.

(See Ordnance Memoranda No. 18, cavalry outfit, p. 67.)

No. 38. Scouting belt.

A leather strap is sewed on to the outside of the belt so as to form a succession of loops. The weight of the cartridges inserted in these loops is consequently disposed uniformly around the waist.

VARIOUS CARTRIDGE-BOXES.

No. 39. Cartridge-box and webbing belt used in the Revolution and in war of 1812.

The body of the box consists of a black walnut block bored with 24 .8 inch holes. Loaned by Mr. Joseph Burge, New Haven, Conn.

No. 40. United States cartridge-box for paper ammunition; caliber .58.

The cartridges, forty in all, are contained in two tin boxes lying within the leather box. The boxes contain two tiers of cartridges. When the upper tier is exhausted the tin is pulled out and the cartridges beneath transferred to the upper tier. This cartridge-box was that mainly used during the war of the rebellion.

No. 41. Cap-pouch.

Used for holding percussion caps in the war of the rebellion. The sheep-skin lining kept them from falling out. Since then extensively used for revolver ammunition, and also proposed to be used for musket ammunition, a number of these pouches being strung around the waist.

No 42. Mann's equipments; caliber .58.

The tin box inside the cartridge-box contains a tray sliding up and down, upon which the cartridges are placed when the box is filled. This tray is pulled up as the cartridges are expended, and thus obviates the inconvenience attending the transfer of the tins as in the regular cartridge-box. The weight of the waist belt is sustained by shoulder straps fastened at each end to the belt. The waist-belt plate is remarkably light. Two boxes are designed to be worn in front, counterbalancing the weight of the knapsack in rear.

No. 43. Mann's cartridge-box, small; for paper ammunition; caliber .58.

See description of large box elsewhere. This box is one of a pair, designed to be worn one on each side of the body. The interior sliding tray is missing.

No. 44. Blakeslee cartridge-box for the Spencer carbine; caliber .52, open.

Consists of a hexagonal block of wood about 12 by 4 by 2½ inches encased in leather, and containing from 10 to 13 tin tubes full of Spencer cartridges, 7 in each. The contents of one of these could be emptied at once into the magazine of the carbine, saving much time over the tedious operation of putting them in singly by hand. The leather case is provided with loops and rings by which it is attached to the equipment. See lay figure representing cavalryman of 1865.

No. 45. Blakeslee cartridge-box for Spencer carbine; caliber .52.

Closed, with carrying strap.

No. 46. Webster's telescopic cartridge-box; caliber .50, open.

The wooden body of the box, pierced for 40 cartridges, slides downward, and permits the insertion above it of 20 more cartridges in the paper box in which they are issued to the troops. These having been exhausted, the body is drawn up into service. When in position the wooden body is supported by straps passing beneath it.

F.—Machinery.

No. 1. Machinery used in the manufacture of rifle blank cartridges; caliber .45.

This occupies a complete set of machines and operatives transferred for this purpose from the Frankford Arsenal, Philadelphia. The capacity of the machines is about 14,000 complete cartridges per day. These are run, at the rate of about 5,000 per day, on an order from the Chief of Ordnance for half a million blank cartridges which will be made here during the summer. On account of the danger, the operation of loading these shells is omitted, but a loading machine is shown which is run at pleasure with mustard seed instead of powder. Frankford arsenal, in the northeastern portion of the city of Philadelphia, is the seat of the manufacture of metallic ammunition for the Army, and of many other special branches connected with the military supply.

The center-fire metallic-case cartridge.—(See Ordnance Memoranda No. 8, revised.) The successful invention of the self-primed metallic-case cartridge has greatly simplified the construction of breech-loading small arms. Prior to its introduction and

use, the prevention of the escape of flame through the joint of the breech mechanism had to be resorted to with at best unsatisfactory results. The metallic cartridge overcomes this difficulty, being itself a perfect gas check renewed at every round; prevents foulness and wear of the mechanism, and exercises the most vital functions in the life of the arm. So important an element is it, that it may be said that, with a perfect cartridge, the most indifferent breech arrangement can be used with safety and efficiency. Its advantages, other than that already indicated, are many; its completeness and simplicity, being self-primed and used as a whole in loading; its strength and safety, withstanding the roughest usage and thoroughly protecting the powder and fulminate; its accuracy, because of the coincidence of the axes of the bore and bullet; and, added to these, the absolute impossibility of using more than one cartridge at a time. The United States regulation center-fire metallic cartridge consists of the following parts, viz: The copper case, the copper-cup anvil .15-inch high, one-half grain of percussion composition, 70 grains of musket powder, and a lubricated leaden bullet weighing 405 grains, 16 parts lead, 1 part tin. The case is the copper tube which forms the receptacle for the powder charge, the percussion composition, and the leaden bullet. Its exterior conformation is designed to facilitate its ready extraction from the chamber of the gun after firing. Besides the rim at the closed end, which is intended, primarily, to assist extraction, the case is tapered from the rear to a point where it seizes the bullet, whence it merges into a right cylinder.

The cup anvil is a small metallic cup, of sufficient rigidity to resist the blow of the hammer communicated by the firing-pin, and of such form as to insure the passage of the flame to the powder charge upon the explosion of the percussion composition. It is provided with a circular recess or cavity into which the percussion composition is deposited.

Two little vents, at the extremities of a diameter of the recess, direct the flame to the charge. The cup, when charged with the composition, is placed within the copper case, pressed snugly against its closed end, and crimped firmly into position. The bullet enters more than half its length into the case, in order that the lubricant in its grooves may be entirely covered and protected. To render the cartridge waterproof, the edge of the case is crimped hard against the bullet.

The case.—The copper: The sheet copper for making the cases is No. 22, wire gauge, obtained in strips 35 inches long, 3.3 inches wide, and from .025 to .027 inch thick. The ends of these strips are cut at an angle to avoid waste, and each strip gives material for 40 cases, with one-fourth scrap.

In the selection of sheets for making the cases, such only should be chosen as appear to have been rolled in a careful manner. They must be free from the slightest seams, blisters, or flaws, and of an even thickness throughout, well annealed, and trimmed to the foregoing dimensions. The best copper ores are mined on the shores of Lake Superior.

The "Minnesota mines" and the most approved brands of "Detroit" smelting should be selected in preparing metal for cartridge purposes. Most of the copper heretofore used at the Frankford Arsenal has been procured from the mills at Bloomfield, N. J. It is not pure as received from the mills, being alloyed with 5 per centum of spelter.

Double action press.—The first operation in drawing the tubes is performed by the double-action press. The strips of copper are prepared for the press by straightening their ends and edges, if necessary, with a hand mallet, and oiling both surfaces. The strips are then fed to the press by hand, a small stop on the die-plate regulating the length of the feed. Two rows of disks are cut from each strip, one disk at a time. They are cut and cupped at the rate of 75 a minute.

Single-action presses.—In order to draw the cups to the dimensions required for the finished cases, they are subjected to the action of five additional punches and dies of decreasing sizes, so as to gradually elongate the cups while reducing their diameter. These draws are made by single-action presses, having each a single punch and die. These presses are fed at the rate of 65 tubes a minute, by placing them upright on a revolving horizontal plate provided with guides and stops.

Portable gas-furnace for annealing cartridge shells.—The cartridges are annealed after the second draw to restore to the metal its ductility, the previous operations having rendered it hard and brittle. This is done in the furnace. The gas mixed with air from the fan blower, and ignited, passes around and through the perforated cylinder containing the cartridge shells. This cylinder is kept rotating by hand till the shells are at a red heat. They are then plunged in dilute acid to remove the scale, and washed.

The furnace here shown is a small one devised for this special purpose. It holds about 1,000 shells.

Drying-press.—To dry cartridges after washing, and also after priming. It consists of several trays with wire-net bottoms set in a cupboard, kept hot by a steam coil.

Trimming machine.—The finishing draw having left the tubes of unequal lengths and with ragged edges, it is necessary, in order to facilitate the subsequent steps of manufacture and insure uniformity in the finished cartridges, to remove the ragged edges, and to reduce the tubes to a uniform length. This is done by means of the trimming machine. The tubes are placed in the trough of this machine, whence they are taken up by a revolving mandrel, against which, and just inside of a shoulder upon the same, the edge of a circular cutter is pressed. The tube, when brought to position by the mandrel, is cut clean and even by the cutter, a stripper removing the tube and scrap after each operation. To allow for the metal that is used in forming the head or rim, the tubes are cut a little longer than the headed case. The tubes are trimmed by this machine at the rate of eighty a minute.

Heading machine.—The head or rim of the cartridge case is formed by the heading machine. This machine consists of a horizontal die countersunk at one end for shaping the head, a feed punch to insert the tubes into the die, and a heading punch to flatten the closed end of the tubes into the countersink. The tubes, which are a little longer than the headed case, are fed into the inclined trough of the heading machine, whence they are taken up on the feed punch. A shoulder on this punch, at a distance from its extremity equal to the inner depth of the headed case, prevents it from extending to the full depth of the tube, and a surplus of metal is thereby left at the closed end of the tube for the formation of the head. The feed punch inserts the tube into the die, and holds it there, while the heading punch moves forward by a powerful cam, and presses and folds the unsupported projecting portion of the tube into the countersink of the die, forming and accurately shaping the head or rim. The headed case being left in the die as the feed punch recedes, is pushed out by the succeeding tube, and thrown by a flipper into the receptacle below. No oil is used in this operation, the moisture of the tubes from the recent washing sufficing as a lubricant. The machine is fed at the rate of sixty-five per minute. The cases are now finished, but to be certain that the oil is entirely removed from them they are again washed in alkaline solution, and dried thoroughly in a drying room at a temperature of about 125° Fahr.

The cup anvil.—The cup anvil is made by a double-action press similar to the one for cutting and cupping the disks for the copper cases. The cups are cut and formed by this machine at the rate of seventy-five a minute.

Cup trimming machine.—The cup anvils, as they come from the double-action press, are of the right diameter, but too long, and with ragged edges. The cups are reduced to a uniform height by cutting off the ragged edges in the cup trimming machine, which consists of a revolving rose cutter, made of a number of small cutters that can be changed and sharpened at pleasure. The cups are fed to the cutters through a vertical trough, and are trimmed at the rate of forty-five a minute.

Cup venting machine.—The vents are punched in the trimmed cups by the cup venting machine, which is provided with a two-pointed punch and corresponding dies. The cups are fed by hand on a revolving circular plate, at the rate of seventy per minute.

Cup impression machine.—The circular depression in the bottom of the cup, which

serves as the receptacle for the percussion composition, is formed by the cup impression machine. The cups are fed through a vertical trough at the rate of eighty per minute. The trough has a flat pan at the top, into which the cups in quantities are emptied, and where they are arranged so as to present the proper end to the punch in passing through the machine. This machine not only forms the recess, but gauges the cup at the same time. The cups thus completed are well washed in an alkaline solution, to remove all traces of oil, and then thoroughly dried.

The percussion composition.—The percussion composition consists of:

	Parts.
Fulminate of mercury by weight	35
Chlorate of potash	16
Glass-dust (broken French plate)	45
Gum arabic	2
Gum tragacanth	2

These are mixed without danger by using the fulminate in a moist state, the water having been entirely drained from it.

Priming machine.—The percussion composition, of the consistency of thick paste, is deposited in the recess of the cup by the priming machine—a very ingenious piece of mechanism which performs this important operation with the greatest accuracy and certainty, and with perfect safety. Its principal parts are: 1st, the central revolving spindle, with four tubular feeders at its head, which deposit the percussion composition in the cups; 2d, the magazine on the right; and, 3d, the circular plate on the left, on which the unprimed cups are fed to the machine. The four tubular composition feeders at the head of the spindle consist each of a small depending stem, down which a closely-fitting tube is made to slide, the lower edge projecting a little below the end of the stem.

By the revolving motion of the spindle these tubular feeders are brought successively over the magazine and over the cups to be primed. At the moment a feeder is presented over the magazine, which is a shallow dish containing the percussion composition, the magazine rises until its metal bottom is in contact with the tube, a slight shaking motion of the magazine during its progress serving to deposit compactly into the open projecting end of the tube a sufficient quantity of composition for priming of a single cup. The magazine then recedes, while the revolving spindle carries the charged feeder to the circular plate on the left, which presents the cups for priming. The motion of this plate is from left to right, while that of the spindle is from right to left, whereby the feeders and cups are made to meet and leave each other in opposite directions. The plate is provided with eight upright movable stems, on the ends of which the unprimed cups are fed. As the cups and feeders are brought, by the revolutions of the plate and spindle, in a vertical line with each other, the cups are raised by their stems so as to receive the percussion composition exactly in their circular recesses from the tubes of the feeders. The tube, at the moment of contact with the cup, slides up its depending stem and frees the composition from its end, which is pressed, by the upward motion of the cup, snugly into the circular recess. The feeders and cups in parting leave each other horizontally, in opposite directions, so that the percussion composition is sheared off evenly and smoothly with the bottom surface of the cup. A specific quantity of composition is thus deposited in the recess of each cup at each operation. The principal difficulty heretofore encountered in perfecting a machine of this kind is entirely overcome by the use of the peculiar feeder. This machine primes at the rate of thirty-five per minute.

Tapering machine.—While the composition is still moist in the circular recesses of the cups, the latter are put into the headed cases and crimped into position, the cases being tapered at the same time. This operation is performed by the tapering machine, which consists of four vertical tapered dies, with stems projecting from their centers on which the cases and cups are fed; the crimpers which work from the sides of the dies; and the descending punch which forces the cases into the dies. The primed

cups are placed on the ends of the stems projecting from the dies, and the cases are placed over them. By the revolution of the horizontal plate on which the dies are placed, each die is in succession brought under the descending punch which forces the cases into the dies, and presses their heads hard against the primed cups, while the crimpers move forward from the side and bite the cups snugly and firmly into place. The central stem rises out of the die as the latter leaves the punch, and the case is removed by a spring. The section of the case which is to envelop the bullet is not tapered by this machine, it being left in the form of a right cylinder whose inner diameter is the same as that of the bullet. This gives the bullet a securer hold in the case, and helps to make the cartridge water-proof.

The bullet.—The lead: The United States elongated service bullets are made by compression by means of machinery adapted to this purpose. They are uniform in size and weight, smoother and more homogeneous, more accurate, and give better results than cast and swaged bullets. The lead for bullets should be pure soft lead of commerce, of specific gravity about 11.35, which is increased by pressure to about 11.45, and which melts at 600° Fahrenheit, and volatilizes at red heat. The lead is first melted and cast in iron molds into cylindrical bars. These bars are passed through rolls which reduce them in diameter. A man will cast, in a day of ten hours, 1,500 bars of lead. A man and boy will roll and trim in a day of ten hours, 3,000 bars of lead.

Bullet machine.—The bars are fed to the bullet machine through a vertical tube above a horizontal cutter, which cuts, at each stroke, a length sufficient to form a single bullet, and transfers it to the die, in which, by means of a vertical punch, the bullet is formed with its grooves. The surplus lead is forced out at the junction of the dies, in the direction of the longer axis of the bullet, and at the junction of the punch and dies at its head. A bullet machine will make in a day of ten hours, 30,000 bullets.

Bullet trimming machine.—The operation of trimming the bullet is performed by the bullet trimming machine. The bullets are fed by hand into a revolving perforated circular plate, whence they are forced by a punch through trimmers which open from the point to the base of the bullet, and which conform to its shape, a cutter at the same time passing over the base. After this they are forced by the punch through a gauge under the trimmer. The bullets do not vary more than one or two grains above or below their prescribed weight. The best lard oil is used with these machines. A boy will trim and gauge, in a day of ten hours, 15,000 bullets.

Lubricant.—The lubricant for bullets is made of bayberry tallow, by weight, 8 parts; graphite, by weight, 1 part.

Lubricating machine.—The lubrication of the bullet is done by the lubricating machine. The lubricant is molded into cylinders of about 10 inches in length. These cylinders are fed to the machine through a vertical tube, pressure being applied to keep the supply constant. The bullets are placed by hand in a perforated revolving vertical plate and forced by a punch through a sizing gauge fixed in the bottom of the tube, which is pierced with small holes. The lubricant is forced through these holes into grooves of the bullet, filling them completely. A gas jet is provided for slightly warming the lubricant. A boy will lubricate, in a day of ten hours, 15,000 bullets.

Loading.—Loading machine: The cases are now loaded with powder and bullet by means of the loading machine, which consists of a revolving circular plate with holes or receivers, and a hopper and powder measure. The cases and bullets are fed on revolving plates, thirty-five a minute; the former are lifted into the receivers, passed under the hopper and measure for a charge of powder, and then under the bullet feeder for a lubricated bullet.

In order to insure a full charge in each cartridge the machine is provided with a bell, which gives notice to the operative of any failure in this particular. The edge of the case is then crimped on the bullet in a very simple manner. The receivers are smaller at the top where the bullet enters than at the bottom where the case is

received, the diameter of the former being only equal to that of the interior of the open end of the latter. After the bullet has been pressed into the case, the cartridge is lifted, so that the edge of the case is forced into the conical surface of the receiver, between its larger and smaller diameters. The powder is placed in a pasteboard hopper, about 2 feet above the machine, and is fed to the cases through a paper tube one inch in diameter; the hopper and tube stand inside of a large conical shield of boiler iron. The loading machine is run upon application by visitors, mustard seed being used instead of powder. After loading, the cartridges are wiped clean, and put up in paper packages, and packed in wooden boxes for storage or issue.

Blank cartridges.—The blank cartridge consists of a copper case; 70 grains of musket powder. The powder is pressed hard in the loading machine and varnished at the open end of the case; no wax or other stopper is used.

Materials required for 100,000 *rifle-ball cartridges, caliber* .45.

	Pounds.
Sheet-copper; one-fifth is returned as scrap	2,500
Hard copper for inside cups; one-third scrap	570
Lead and tin; 16½ scrap	5,785
Lubricant for bullets	60
Musket powder	1,000
Percussion composition	7.5

Machines required to make 100,000 *bullet-cartridges a day.*

No.	Machines.	Working capacity of each in ten hours.
	FOR CASES.	
4	Double-action presses	28,000
16	Single-action presses	26,000
6	Trimming machines	18,000
4	Heading machines	26,000
7	Tapering machines	16,000
7	Loading machines	16,000
2	Annealing furnaces	
	Wash tubs, barrels, trays, &c.	
	FOR CUPS.	
5	Double-action presses	22,000
4	Vent punching machines	28,000
6	Trimming machines	18,000
4	Impression machines	28,000
7	Priming machines	16,000
2	Tinning furnaces	
	FOR BULLETS.	
4	Bullet machines	28,000
7	Ball trimmers	16,000
7	Ball lubricating machines	16,000
2	Sets of rolls	
	Lead pots, mold, &c.	
	FOR PAPER BOXES.	
1	Paper cutter	
2	Creasing machines	
6	Single presses	
1	Printing press	
	Type, &c., wooden formers, paste kettles, brushes, knives, &c.	

Dimension and weights of rifle-ball cartridge, caliber, .45.

Case:

Extreme length of case	true inch..	2.1
Diameter before tapering		

Diameter under head, after tapering	true inch..	.505
Diameter at open head, after tapering	do.....	.48
Diameter at head	do.....	.61
Thickness of head	do.....	.067
Cup:		
Height of cup	do.....	.15
Diameter of cup	do.....	.453 454
Diameter of recess	do.....	.15
Depth of recess	do.....	.025
Diameter of vents	do.....	.07
Bullet:		
Length of bullet	do.....	1.11
Diameter of bullet	do.....	.458
Length of finished cartridge	do.....	2.535
Weight of case	grains..	150
Weight of powder	do....	70
Weight of percussion composition	do....	.5
Weight of bullet	do....	405
Weight of finished cartridge	do....	631.5
Weight of package of 20 rifle-ball cartridge		1 lb., 15 oz.
Weight of box of 1,000 rifle-ball cartridge		187 pounds.

No. 2. Tools and gauges used in the manufacture of metallic ammunition.

1. Dies and punches in section for cupping press and five drawing presses in detail; showing cartridge case in section in its passage through the different dies, with sample specimens of cases in different stages of completion.

2. Five dies for same with stand and plug gauges used in maintaining the hole in the dies at their exact size; also, receiving gauges for measuring points of drawing punches.

3. Specimen of spindle and revolving cutter used in trimming cartridge-shell.

4. Gauge used in trying length of trimmed shell.

5. Heading punch and die, containing cartridge in section, with gauges for head recess in die; also, heading-die gauge and heading die in full relief.

6. Section of double-action punch and die for cup anvil, with gauges for point of punch and hole in die; also, die in relief.

7. Cup, impression die, and double punch in section, containing cup anvil in process of impression, with male and female impression punch-gauges.

8. Gauges for measuring thickness of cup anvil and maximum and minimum diameters.

9. Six specimens showing progressive stages of manufacture of cup anvils.

10. Bullet cast.

11. Bullet rolled.

12. Bullet swaged; showing two halves of die with punch and bullet in section.

13. Bullet trimmed, showing tool in section with bullet in relief inside.

14. Specimen of priming magazine, containing moist fulminate used in priming cartridge-shells with hollow spindle used to transfer priming to cup anvil.

15. Shell in relief in sectioned die, showing operation of crimping cup anvil.

16. Shell in relief in the sectioned die, showing operation of "crimping in" the bullet.

17. Complete shell in relief and in section, with bullet in place.

18. Gauges for measuring thickness of sheet metal used in cartridge manufacture.

19. General gauge for inspection of cartridges, testing maximum and minimum diameters of cartridges; also, length and thickness at different points.

20. Maximum and minimum gauges (standard chambers) for finished cartridge shell.

No. 3. Machinery used in the manufacture of Springfield breech-loading rifles; caliber .45.

This is conducted by armorers specially detailed for this purpose. It was manifestly impossible to transfer to the exhibition the entire plant of the armory. So only special representative machines were selected for the display. In this manufacture are shown types of every process used in gun manufacture, many of them originating in the armory workshops. The National Armory at Springfield, Mass., was first set in operation in about 1792. Its production during the recent civil war was at one time one thousand new muzzle-loading rifled muskets per day, employing about three thousand men, at a cost of about $12 per musket. Its capacity for breech-loading rifles has not since been tested to extremes. The arms as now made, at the not economical rate of from sixty to one hundred and fifty per day, cost about $18 each, allowing for the value of many parts derived from the old muzzle loaders.

Drop hammer.—The hammer, weighing 400 pounds, is raised by means of the plank fastened to it and passing between two rollers at the upper end of the ways. These rollers revolve in different directions, and ordinarily without touching the plank. By means of the treadle the rollers are brought together, and pinching the plank between them raise the hammer to the required height. It may be held there by a pawl upon one of the ways and dropped with a fixed blow, or may be let fall from an intermediate point with a varying blow. The other principal features of this machine are the solid ways with their adjustment for wear and the continuous treadle. This machine represents the operation of breaking down or shaping, forging, or bending hammers, butt-plates, and side-screw washers. Lead is used for this purpose instead of bars of hot iron.

Drop hammer made by Pratt & Whitney, Hartford, Conn.

Water front forge.—The door of this forge is a hollow casting filled with flowing water, intended to protect the smith from the heat of the forge fires. The feed-hopper is also shown, by which the coal is thoroughly and gradually heated before combustion.

Boring-lathe for barrels.—On this are illustrated two operations of boring.

1. Nut-boring: In this boring the auger is welded to the end of a stem, which, being smaller than the auger, is slipped through the barrel, fastened to the head of the lathe, and set revolving. Meanwhile the barrel is slowly pulled backward by means of a weight, or in some machines by hand. The edge of the auger next the stem being sharp cuts out the burr. (See Benton, p. 323.)

2. Reaming: The hole having been made with approximate exactness, and the sides being clear from slag, scale, &c., a square auger or reamer is introduced into the barrel and caused to revolve. It is caused to cut on two of its edges by wedging together between the opposite side of the auger and the side of the burr, a half-round fine strip called a chip. As the caliber increases the wear is taken up by strips of paper laid in between the auger and the chip. The barrel in this operation is caused to move along the the reamer by means of a crank and a rack and pinion connected with the carriage to which the barrel is secured. The speed of this operation varies, the last reaming before rifling being done with great rapidity. Cost, $280.

Barrel-turning lathe, second turning.—Resembles an ordinary engine lathe except in the following points: The turning tool is caused to approach and recede from the center of the barrel so as to give it its form by means of the tapered slide upon which the outer end of the slide-rest travels. At the high part of this former the tool is thrown in towards the center; at the low point it is drawn back from it. The progress of the slide-rest when the end of the barrel is reached throws out of gear a clutch upon the head of the lathe and brings the operation automatically to a close. For the first turning the barrel is supported by a back-rest at its middle point. At this point upon the barrel is cast a ring of Babbitt metal trued off from the center of the bore. The barrel is second-turned without the use of this ring, as in this case, but a light chip is taken on the second turning. The oil-can fastened to the slide-rest travels

with it and keeps a stream of oil constantly running upon the tool. Cost, $440. Use, turning barrels. Made at United States Armory, Springfield, Mass.

Straightening-stand.—Inasmuch as the operations of boring &c., are apt to leave the bore not absolutely cylindrical, it is straightened by laying the barrel across the two blocks on the anvil belonging to the stand and rapping it with a hammer. The irregularity of the bore is ascertained by looking through it at a horizontal line upon a ground-glass shade, turning the barrel meanwhile upon its own axis. The image of this line is reflected upon the polished sides of the bore, in straight converging lines, if the bore be true. If not true, a wave is observed at the crooked point, which is rendered more evident by the revolution of the barrel. The straightening has all to be done before the barrel is rifled; after that the grooves interfere with the clearness of the lines.

Trimming-press, two specimens, one by hand, one by power.—In the operation of the forging, the excess of metal over that necessary to fill the dies is pressed out between their edges and forms a border known as the fin. The trimming-press cuts off this fin as follows: Upon its bed is a die of steel cut through in the exact outline of the finished piece. The other die, moving up and down in the way of the frame, is made in the form of a projecting tenon, just fitting the hole in the die beneath. This presses the body of the piece through the hole in the lower die, leaving the superfluous edges behind. For trimming iron specimens these presses run by power. Cost, $140. Works on one made at United States Armory, Springfield, Mass.; the other by Snow & Brooks, Meriden, Conn.

Rifling machine.—The three cutters attached to the rifling rod are caused to reciprocate longitudinally through the barrel by means of the endless chain connected with the driving pulley. A transverse rotary motion is also given by means of the rack attached to the side of the frame. The combination of these two motions produces the spiral twist or rifling. In order to produce uniformity in the cut at each stroke of the rifling rod, the bell-crank lever on the side causes the barrel to make one-third revolution. This brings each one of the three cutters successively into every one of the three grooves. As the rod moves forward a projection on the ways strikes against sliding transverse arm upon the carriage which carries a pawl and causes it to give a partial revolution to a toothed wheel at the end of the rifling rod. This wheel is connected with a spindle running longitudinally through the rod, having a conical termination at its further end, just beneath the cutters on the rifling head. (See sectional specimen with rifling machine.) As this wheel revolves it pushes forward this conical head against the under side of the cutters and causes them to expand slightly so as to deepen their cut in the barrel. As the rifling tool emerges from the barrel it passes through a jet of oil pumped up by a pump attached to the driving pulley, which effectually washes off the chips and lubricates it for a fresh stroke. The oil runs back, and is used over and over again. Twist, one turn in 22 inches. Made by R. Hoe & Co., New York and Boston. Cost $1,100. Use, rifling barrels.

Polishing-stand.—The "bluff wheels" are made of wood covered with a tire of leather secured by pegs. The leather is coated with glue and rolled in powdered emery or corundum. Used in polishing various components of arms, many varieties of wheels being used. Works upon butt-plates, bayonets. Made at United States Armory, Springfield, Mass.

Drilling-press.—The two upright spindles carry drills set in revolution by the belting above. The piece to be drilled is held in a hand-fixture called a gig, and resting upon the table is brought up to the drill by means of the foot-lever on the side of the machine. In the gig the holes through which the drill passes to reach the work are lined with steel bushings, flaring outwards to guide the drill. Besides strict drilling and counterboring, this machine is sometimes used for end-milling, a cutter with teeth upon its end being used for making approximately conical surfaces. Hollow cutters are also used for milling tenons, &c., as in side-screw washers. Cost, $350.

Works on butt-plates, pins, screws, and washers. Made at United States Armory, Springfield, Mass.

Profiling machine (sometimes called edging-machine).—A modification of the lathe for turning irregular forms (*q. v.*) There are two pair of pins, one fixed and smooth, called the guide-pin, the other revolving, and cut-in teeth, called the cutter. There is also a pattern in steel of the shape to be cut, called the former, side by side with the fixture intended to hold the piece itself. The pins can be lowered so that the guide-pin will enter the "former"; when in position a catch upon the frame keeps them from rising. Having set the cutters in motion, they are brought against the work, at any desired point, by means of the two handles on the table, one of these handles giving a longitudinal motion to the fixture holding the work, and the other handle giving a transverse motion to the frame to which the cutter and guide-pin are fastened. The perfect parallelism of motion thus obtained between the cutter and its guide-pin secures a perfect reproduction of the former. The second cutter and guide-pin are employed to finish the cut roughed out by the first pair. The guide-pins are made taper at the portion in contact with the "former," so that by driving them in or drawing them back the cutter may be adjusted so as to trim off less or more of the work. Cost, $545. Works upon lock and butt plates, hinge-pin. Made by Wood & Light, Worcester, Mass.

Milling-machines.—The revolving mills are provided with teeth which, as they turn, cut upon the work a profile, matching their own. By suitable connections the work is gradually drawn beneath them, and this profile indefinitely repeated across the area of the whole piece. Thus a cylindrical mill cuts a plane surface, as seen in the machine-milling lock-plate. A barrel-shaped mill cuts a hollow surface whose elements are straight lines at right angles to the axis of the mill. By combining cutters of different form upon the same shaft a great variety of surfaces can be cut. Even this arrangement is varied, however, in the two machines engaged in milling butt-plates. Here, in order to suit the wavy form of the line of the plate, and to turn the corner at the junction of the sole and the tang, a reciprocating motion is given to the fixture holding the butt-plate as it goes under the mill. The fixture holding the work is hinged at its forward end on a horizontal axis. Beneath the upper flap so formed and fastened to it is a web, cut out to correspond to the line of the butt-plate. As this web moves on it passes over a stationary cross-bar, which causes both the web and the butt-plate above it to rise or fall under the mill according as the web projects or is cut away. This is called a bridge-milling fixture. The work is gradually carried under the mill by a screw motion, which stops automatically as soon as the cut is completed. The work is then rapidly withdrawn by hand. Cost, $270 each. Works upon butt-plates, receivers, hinges, pins, washers, lock-plates, &c. Made by Ames Manufacturing Company, Chicopee, Mass.

Emery-grinder.—Consists of a spindle revolving at a very high velocity, upon which are fastened wheels composed of emery or corundum and glue pressed up in a mold. Used in grinding the edges of all sorts of cutting-tools, particularly for the mills; the true cylindricity of which is preserved by their being held during the grinding upon an arbor on which they revolve. This special feature is not represented on this machine. Made at United States Armory, Springfield, Mass. Use, grinding cutters.

Clamp milling-machine.—For cutting out irregular forms of a circular cross-section whose axis is a straight line. At work generally a wire or a blank screw is clamped firmly in a holder connected with the head-stock, and caused to revolve between a pair of stationary jaws provided with longitudinal teeth and formed so as to partly inclose the work. The file of the jaws corresponds with the form desired to be given to the piece. Cost, $270. Used in making the firing-pin, head of the ramrod, circumferential grooves in end of ramrod, milling forged butt-plate screws preparatory to cutting thread, &c. Made by R. Hoe & Co., New York and Boston.

Screw-cutting machine.—The wire is passed through a hole in the axis of the head-stock of the lathe, and confronted with a series of cutters, &c., and on the side of a disk-

shaped holder attached to the tail-stock. This holder is movable by hand, so that each cutter upon it shall come successively opposite to the end of the wire, and be held there firmly until moved on. The first piece on the holder is the stop, which regulates the length of the screw to be made. The wire being set by this stop is clamped firmly in the head-stock and set revolving. The holder is rotated so that the next cutter comes opposite to the wire. By means of the hand-lever the entire holder is then brought up to meet the wire to allow the hollow mill which it contains to pass over it. This mill reduces the size of the wire to the full size of the head of the screw. The next cutter has a smaller hole and shorter reach, and cuts out the stem of the screw to size, and crowns the end. The machine is then stopped, and the next cutter, which makes the screw-thread, run on by hand. Starting the machine again the screw is cut off by an ordinary lathe-tool on the side of the machine. The slit is made separately in another machine. Screw-cutting machine, made by United States Armory, Springfield, Mass. Use, screws and swivels. Cost, $240.

Second-drilling receivers (sometimes called gang-driller).—This machine closely resembles the screw-machine (*q. v.*) It operates conversely upon the materials, however, the cutters penetrating the receiver instead of enveloping the wire, as in the former case. There is a succession of these drills or counter-bores of increasing size, which enlarge the hole made through the receiver by the operation of first drilling. A force pump attached to the driving mechanism forces a stream of oil into the hole as the cutters are withdrawn from time to time, and washes out the chips. One peculiarity consists in the use of a hollow finishing counter-bore, through which a stream of oil is kept running while the tool is at work. The large wheel serves to press the tools well against their work. By examining the specimen boards it will be seen how much work is imposed upon this machine in regard to the quantity of material it removes. Cost, $800. Use, enlarging bore in receivers. Made by Pratt & Whitney, Hartford, Conn.

Engine-lathe.—An ordinary engine-lathe used in making repairs to tools, fixtures, &c. Cost, $320. Made by Wood & Light, Worcester, Mass. Used in making and repairing of tools.

Stock-turning (*butts*).—The stock having been sawed, centered, and having had the tip roughly turned, is brought to this machine, being set by the center marks in the butt, the tip is passed through a holder and clamped. The part to be turned is then inserted over an iron pattern of the work required called the former (see profiling machine). Resting against the former and the rough stock is a rocker, the lower end of which, near the floor, is traversed by a shaft running the length of the machine. This permits it to swing back and forth at right angles to the work which, with the former, has a motion of translation in the direction of the length of the machine. The rocker carries at its upper end two wheels of equal diameter, one a blank wheel of iron called the guide-wheel resting against the iron former; the other, consisting of several spokes armed at their extremities with sharp steel cutters, occupies a similar position against the wooden stock. The cutters have an independent connection for giving them an extreme velocity of rotation. Now the function of the machine is clear. Being set in motion, the gun-stock and former both slowly and at the same time pass along in front of the cutters and guide-wheel as they revolve. The former, by its influence upon the guide-wheel, throws the cutter above it out and in, according as the guide-wheel happens to rest upon projections or retired points upon the surface of the former. The result is that the cutters follow the transversal indications of the guide-wheel, and, having also, as before described, a relative motion of translation along the stock by a long spiral cut, reduce it to the form desired. This operation is repeated in the finish-turning which, making a fine and narrower groove, leaves less prominent ribs to be scraped off by hand by the finishers. The operation of turning the tip, before referred to, is conducted on precisely similar means, but was omitted from the representation on account of the great irregularity of the butt portion of the stock and the greater consequent interest of the operation. This machine was

devised by Thomas Blanchard and James Stillman, employés of National Armory, Springfield, Mass., in about 1820. The original machine may still be seen at the armory. It was the parent of a great variety of similar machines used in turning spokes, ax-handles, shoe-lasts, &c., which have been of inestimable benefit to American manufacturers. Cost, $1,100. Use, turning butt-stocks. Made by Ames Manufacturing Company, Chicopee, Mass.

Lock-bedding machine.—For cutting out the seat of the lock in the gun-stock. This operates precisely upon the principle of the profiling machine before described. The only essential difference being that in this case, on account of the greater variety in the diameters of the holes and curves to be produced, and the consequently increased number of cutters and guide-pins, the latter are arranged upon a reel instead of side by side as in the profiler, so as to save room. The arrangement for automatically shifting the belt on and off the spindle is especially interesting. Cost, $1,900. Use, bedding gun-locks. Made by Ames Manufacturing Company, Chicopee, Mass.

Fixture for bending gun-sling swivels.—The swivels made of wire are passed through holes in the lug of the band and kept there by a transverse pin. The band is then clamped securely in place. The two handles are then swung around so as to bend the wires together around the elliptical former. Each handle is connected with the main axis by means of a link which allows the operating end a compensating motion, giving it an opportunity to iron in each portion of the wire successively without dragging along its surface. The operating end of the lever is grooved for each one of the two wires forming the gun-sling swivel and stacking swivel on the upper band. A machine like this is used to bend the guard-bow. Made at United States Armory. Use, bending swivels and stocking hooks.

Machine used in making spiral wiping-brushes.—A proper quantity of the bristles are weighed out into bundles, and cut to lengths of about one inch by hand with the eccentric cutter attached to the machine. The short bristles composing one of these small bundles are spread out between the halves of a brass wire bent double at its middle, where it is held by the thong-socket. This end of the wire has been previously clamped in the head-stock spindle on the right of the machine to which the hand fly-wheel is attached. The other end is also clamped in a spindle through the tail-stock. The latter spindle being held fast and the fly-wheel being turned, the wire is twisted up, holding the bristles tightly between its folds. The bristles are then equalized by the rotary cutter which travels on ways at right angles to the brush. The tail-stock spindle having been released, the brush is turned by hand to bring every portion of its surface in the range of the cutter. Made by United States Armory, Springfield, Mass. Use, making wipers. Cost, $75.

Assembling bench.—Designed to illustrate the manner of assembling or putting together the component parts of the Springfield breech-loading rifle; caliber .45; also, to manifest the complete interchangeability of its parts.

G.—INSTRUMENTS.

Before guns or projectiles are accepted by the Government and issued for service, they are carefully inspected to see that they are of the proper dimensions, and that the material of which they are made is not defective. The instruments used in these inspections and exhibited are:

I. For *cannon*: The cylinder-gauge, the star-gauge, trunnion-square, trunnion-rule, calipers, standard scale, vent-gauges, vent-searchers.

II. For *shot and shell*: Ring-gauges, shell-calipers, and gauges for measuring the thickness of metal at the fuse-hole.

1. *Cylinder gauge.*—Used in inspection of cannon to determine if the bore is sufficiently large at every point. It is screwed on to the staff and shoved to the bottom of the bore, previous to the inspection with the star-gauge. (See Ordnance Manual, pp. 26, 27.)

2. *The star gauge.*—This instrument is for measuring the diameter of the bore of a gun at any point. It is applicable to either smooth or rifled guns. Its important parts are the head, staff, handle, guide, measuring points and rests.

The *head* is a brass cylinder, having four steel sockets to receive measuring points for smooth-bore guns, let into its circumference 90° apart and in a plane at right angles to the axis of the head. Two opposite ones are fixed and two are movable radially, and are retained in position by spiral springs. In another transverse plane, near the end of the head, are three similar sockets to receive measuring points for rifle guns, one of which is let into the circumference; the other two are inserted in brass segments occupying segmental slots in which they can be moved tangentially and clamped in position by means of a screw and annular slot in a plate on the end of the head. These three sockets have a radial motion also, and are retained in place by spiral springs. The movable sockets are pushed out by means of a conical steel slider free to move longitudinally in the axes of the head. This slider tapers .3 inch in a length of 2, so that by pushing it .1 inch of its length the diameter of the circle around the points is increased .015 inch.

The *staff* is made in sections 40 inches long. Each section consists of a brass tube inclosing a square steel rod. Both tubes and rods screw together end to end, and any number of sections constitute when assembled a continuous brass tube and inclosed steel rod. The steel rod operates the conical slider. The brass tube is divided into inches and quarters, beginning at the measuring points, so as to indicate the distance of the latter from the muzzle of the gun.

The *handle* is a brass cylinder, and, when attached, incloses a part, and forms a continuation of the staff and inclosed sliding rod. In the tube of the handle there is a slot on the side of which a scale is marked which indicates the movement of the points. Near the end of each section of the staff is a line marked on a small inserted plate of silver which shows the place of zero on the scale when the points are adjusted to the true diameter of the bore. The zero line on the scale and the line on the staff are made to coincide by turning the milled ring on the middle of the handle, and when so adjusted the handle is firmly fastened on the staff by means of a screw-clamp.

The *guide* is intended to keep the points on the lands in the bore. There are two guides; one fixed in the head for the 3-inch rifle; the other is detached and can be used for all other sizes of bore. It is put on the end of one of the measuring points, the latter projecting through it, and it has studs that rest against the sides of the land and whose distance apart may be varied to suit different widths of land.

The *points* are of steel with screw-threads for attaching them to the sockets in the head. Points of a suitable length are provided for each caliber of gun to be measured. A ring-gauge for each caliber is used for adjusting the instrument.

The *rests* are used to support the staff; one in the form of a T is placed in the muzzle to keep the instrument in the axis of the bore. This rest can be adjusted to the different sizes of bore, and the upright branch is movable for convenience in packing. Another rest is used in long guns to prevent deflection of the staff from its own weight. It is clamped to the staff at the place desired, and has sockets into which two of the measuring points made for a gun of less caliber than the one being measured are screwed, and the ends of these are protected from wear by shoes having rollers to facilitate its movement along the bore.

3. *Trunnion-square.*—Used to verify the position of the axis of the trunnions. The two branches, separated by a distance equal to that between the rim bases of the gun, are fitted on the trunnions, and the sliding-point midway between them pushed down on the upper surface of the gun. The gun is then reversed and the square applied in the same manner to the opposite side of the gun. If the branches fit the trunnions, and the sliding-point, without correction, touches the surface of the gun, the axis of the trunnions and gun are in the same plane.

4. *Trunnion-rule.*—For measuring the distance of the trunnions from the breech of the gun.

5. *Calipers.*—For measuring external diameters.

6. *Standard scale.*—For verifying other instruments.

7. *Vent-gauges.*—To determine size of vent.

8. *Vent-searcher.*—To detect presence of cavities.

9. *Ring-gauges.*—For determining exterior diameters; two for each calibre; those for grape and canister attached to the same handle. The projectile must pass in every direction through the larger, not at all through smaller gauges.

10. *Shell caliber.*—For measuring thickness of metal at the sides and bottom of the shell.

11. *Gauges.*—For measuring the thickness of metal at the fuze-hole and its dimensions.

(For description of inspecting instruments, *vide* Ordnance Manual, pp. 25 and 38; Benton, pp. 90 and 200.)

LABORATORY.

Contains the machines used in determining the initial velocity of projectiles, the specific gravity of gunpowder, the pressure on the bore of a gun, and its recoil. Also, the fuzes and friction primers used in the service; inspecting instrument for guns and projectiles; sample targets and the exemplification of various subjects connected with experiments in ordnance. Intended simply to exhibit the means and methods employed at the various arsenals in testing guns and powder, the charges used in the cartridges fired here are reduced from 70 grains (the service charge) to from 10 to 13 grains. This reduction in the charge prevents the disagreeable effect of a loud report, and by the low velocities generated enables a more appreciable record to be exhibited on the machines than the short distance between the targets would otherwise allow.

DESCRIPTION OF LABORATORY BUILDING.

53 feet 3 inches by 23 feet 10 inches. Designed by Col. T. T. S. Laidley, U. S. Ordnance Corps.

Foundation, wooden piles; frame, wrought iron, riveted, covered with a light casing of wood. Designed to prevent the great loss of life that usually results from the demolition of the building, as ordinarily constructed, by the explosion therein of even a comparatively small amount of powder. The frame, rafters, and purlins are wrought iron, securely joined by riveting. The sheathing is light wood, so arranged as to resist the pressure of winds from without, but to yield readily to slight pressure from within. In case of an explosion the roof and sides fall off at once, and the iron frame remains standing to shield the inmates from being buried beneath the ruins. Number and size of windows and doors with same intention. Erected to show principles of construction, wrought-iron stanchions being shown between wooden panels, and recesses cut to show framing. To contain ballistic machines in operative condition. Construction of the building and contents on exhibition. An explosion of from 600 to 800 pounds of powder in this building occurred in August, 1875. The iron frame was uninjured, and the building was restored with a very slight addition of new material. Of the twenty-one persons employed within the building at the time of the explosion, only three boys died from the burns or other injuries at that time received.

No. 1. Fixed rest.

The fixed rest is designed to afford a strong and firm support to the gun when fired, preventing undue strain, but permitting steady recoil, and a facility in pointing and adjustment. The support consists of a cast-iron bed plate, secured to a heavy wooden base; this supports, by means of an elevating screw and trunnion plates, a metallic frame. The points of support, in addition to the butt-stop, are two in number, one

near the butt, the other at about 30 inches in front. These points form part of a bed, which is secured to the frame beneath by guides which permit the bed to slide under the influence of the recoil of the gun. The gun can be elevated, depressed, or traversed in the frame, to an extreme nicety, and can be readily detached. *Vide* Ordnance Memoranda No. 8, p. 36.

No. 2. Targets.

They are separated by a distance of 35 feet, and the space is inclosed in an iron tube for safety in firing. The first target consists in a double wire which is attached to screws forming part of the circuits connecting with the different machines. In firing, this wire is cut by the projectile and the circuit consequently broken. The second target consists of an iron plate. A spring in rear, resting upon it, forms one pole of the current, and when the shot strikes it the spring flies back sufficiently to break the circuit, and then returns to its place and adjusts the target for another shot. As but one battery is used for the two targets, the current is transferred, when broken, from the first to the second, by connecting one wire with each target, the other wire to the first, and thence, when the current is broken there, to the second. The same target answers for all the machines, but, in the case of the thread velocimeter, thread replaces the copper wire; is cut at the first target by the bullet, and released at the second by a lever. *Vide* Benét's Chronoscope, p. 36, and pamphlet on Thread Velocimeter, page 5.

No. 3. Benton's electro-ballistic pendulum.

The two pendulums are supported by the magnets at each end of the horizontal limb, while they remain in the electric currents connected with the targets. By a mechanical device both currents can be broken simultaneously, and the pendulums falling pass each other at the lowest point of the arc. When the circuits are broken by the passage of the shot, the pendulums fall successively, and the number of degrees on the arc included between their points of passage and the lowest point gives, by comparison with previously-calculated tables, the time intervening between the rupture of the first and second targets. The limb is divided into degrees and fifths. The pendulums are supported in a horizontal position by two electro-magnets capable of adjustment and connected each with a battery of two cups. The disjunctor breaks both currents at once and indicates thereby what correction must be made in the magnet to insure the pendulums passing each other at the lowest point of the arc. The inner pendulum carries a lever, the point of which is covered before firing with a small quantity of printer's ink.

No. 4. Benton's electro-ballistic pendulum.

When the two pendulums pass each other a projection on the outer strikes the lever and presses the marking point against the arc, leaving a dot to indicate the point of meeting. (*Vide* Benét's electro-ballistic machines; and Benton, p. 388.)

No. 5. Benton's thread velocimeter.

Tightened thread is used instead of electricity to transmit the impression of the ruptures of the targets by the bullet to the machine. This is placed at the same distance from each target, and consequently the loosening effect of the thread when cut is transmitted insensibly the same time from each. The pendulums are supported by two lever compressors, which are pressed against them by the tension of the thread. In other respects the velocimeter resembles the Benton's electro-ballistic pendulum. A disjunctor knife is used in determining any accidental error in the machine. (*Vide* Benton's pamphlet.)

No. 6.—Le Boulengé chronograph.

Two targets in separate electric currents, placed at a known distance apart, are connected through magnet; the first with the longer, the second with the shorter rod.

As the projectile cuts the first target the longer rod commences to fall; when it cuts the second, the shorter falls, and releases a knife, which indents the zinc-enveloping tube of the longer rod. The distance between this point and an origin based on the time allowance of the longer tube, and previously established on it, is applied to a scale, which gives at once, according to the law of falling bodies, the time taken by the projectile in passing over the distance between the targets. The longer rod is called the chronometer, and is enveloped by a zinc tube called the recorder. The shorter tube is called the registrar, and, falling, strikes a lever and releases a circular knife called the indenter, which makes a cut upon the recorder. The point at which the shorter tube strikes the lever can be regulated by a screw, to adjust it in such manner as to insure the cut being made when both tubes fall together, at a point agreeing with the disjunction mark on the scale. This scale can be read to the thousandth of an inch, and for a distance between targets of 100 feet the velocity can be taken directly from it. This disjunction mark is completed for Frankford Arsenal, and corresponds to a height of 0.15 inch from the origin recorded by the knife when the chronometer is at rest and the registrar released; and clears the readings of errors arising from remaining magnetism and other unavoidable defect in the machine. A disjunctor is used to determine the correction necessary to be applied in the distance between the registrar and the knife lever, and brass tubes are supplied to adjust the strength of the magnets. When the gun is fired, the distance in inches between the disjunction mark and the cut, measured by the scale, gives, by comparison with the table calculated for 35 feet, the initial velocity. Two Bunsen cups are used for the registrar, three for the chronometer.

No. 7. Schultz chronoscope.

The length of time a projectile takes in passing over a known distance is measured by the number of vibrations of a tuning fork recorded upon a revolving cylinder, the number of vibrations per second having been previously ascertained. The cylinder can be given a motion of rotation by tightening the clamp screw which connects it with the clock work, and a motion of translation by closing the vent in which the translating screw works. Its surface is covered with a thin coat of lamp-black. The vibrating fork, connected with the iron bed-plate, is placed in front of the cylinder. A quill point attached to the left branch of the fork and pressed upon the cylinder describes a helical line when both are in motion; a right line when the fork is at rest and the cylinder moving. A second quill point can be pressed by its lever into the cylinder below the first, permitting both curves to be described at the same time.

Russell's interrupter consists of a small steel spring supported near the right branch of the fork, the distance between them being regulated by an adjustable screw. The fork and the screw form the opposite poles of an electric current, which also passes through the magnets on both sides of the tuning fork. When this spring is brought in contact with the fork, the circuit is completed and the magnets draw the branches of the fork apart. This motion breaks the circuit again, the magnets release the fork, and the circuit is again completed, and the magnet excited by the contact of the spring. By this means the vibrations of this fork are originated and sustained.

Ruhmkorf's Coil.—The primary wire is connected with the battery and the targets one end of the secondary is brought through a glass tube in front of the rear cylinder and just over the left branch of the fork; the other connects with the bed plates and through the frame-work to the cylinder. When the primary current is broken by the rupture of the targets, the interruption in the reduced secondary current causes a spark to pass from the glass point to the face of the cylinder, where a bright mark made through the lamp-black indicates the instant of rupture.

The pendulum is used to determine the exact number of vibrations of the fork in a second of time. Below it is an insulated upright spring, forming one pole of the primary current of the Ruhmkorf Coil, the other pole being formed by a metallic stand, against which the spring presses and completes the circuit, when not disturbed

by the pendulum. When used the primary wires are transferred from targets to this machine, and points attached to the pendulum break at each double beat the connection between the spring and the metallic stand, which produces a spark upon the cylinder, as in the case of the rupture of the targets. A mean of the number of vibrations recorded on the cylinder in an observed number of seconds gives the *tirage* of the fork.

The micrometer permits a reading of the five-hundred-thousandth part of a second by dividing a double vibration, which represents about the two hundred and fiftieth part of a second, into two thousand parts.

The batteries.—A Bunsen battery of two or three cups using bi-chromate of potassa instead of nitric acid is connected with the Ruhmkorf Coil and the targets; four cups connected with the fork and interrupter. The liquid in the cups is renewed once a week. The cylinder being in motion and the fork recording on its vibrations, the sparks indicating the instant of rupture are registered to the right of the curve. The machine having been stopped, the time is then ascertained by counting the vibrations and parts of vibrations included between the sparks. (*Vide* Benét's Chronoscope, p. 32.)

No. 8. Vignotti's machine.

The time corresponding to the passage of the projectile over a measured interval between two targets is determined by the length of arc on the limb included between two marks on prepared paper, made by electric sparks produced successively at the instant of rupture of each target, and passing from the pendulum to the brass plate in rear of the paper. The time corresponding to this length of arc is found by reference to a computed table of the times which the pendulum takes in passing over different degrees. In the limb, the annular slot exposes the paper to the induction spark. The pendulum carries a needle which forms one pole of the secondary current of the Ruhmkorf coil, the primary wires of which are connected with the target. The brass plate in rear forms the other pole. The paper used is saturated with a solution of ferrocyanide of potassium to render it sensitive to the heat of the spark, and which perforates it when the targets are ruptured. The circuits having been completed between the batteries, the target, and the machines, the pendulum is supported at the zero of the scale by the electro-magnet. A drop is so arranged at the gun that when it falls it first breaks the circuit which excites the magnet, causing the pendulum to fall, and then fires the gun. Two sparks passing from the pendulum to the brass plate indicate, therefore, the instant when the targets are ruptured, and the arc between them corresponds to the interval of time required. A battery of two cells is connected with the coil and the electro-magnet respectively. (*Vide* Benét's Electro-ballistic machines, p. 12; and Benton, p. 388.)

No. 9. Gun pendulum eprouvette.

Was one of the earliest machines devised for determining initial velocities, and consists of a small gun suspended as a pendulum from a frame. The amount of recoil impressed upon it by the discharge can be measured by means of a graduated arc which moves with the gun, and a pointer which remains fixed during the recoil, and the velocity calculated from the quantity of motion obtained.

As an eprouvette the gun was formerly used in testing gunpowder. The range obtained with a given weight of powder and a standard projectile was called the "proof-range," assumed as a test of its strength, and was marked on the head of the barrel when ready for issue. This test is now entirely superseded by that for initial velocity. (*Vide* Benton, p. 388.)

No. 10. Recoil dynamometer.

The recoil dynamometer consists of a spiral spring which moves by its compression upon a horizontal scale which has been previously graduated by actual weight applied to the same spring when in a vertical position. It is fixed at an initial ten-

sion of 50 pounds to limit the the motion of the gun itself, when fired, by approximating to the amount of the recoil anticipated. The gun is slung by a slight strong rod, and the direction of its motion insured by guides which are not in actual contact with it. The butt-plate heel is adjusted so as to fit in the center of the face of the recoil block; a bridle secures the small of the stock to the case of the dynamometer and prevents the gun from being thrown forward by the return of the spring after the recoil. (*Vide* Ordnance Notes No. 31, and Ordnance Memoranda No. 8.)

No. 11. Rodman's pressure gauge, external.

This instrument depends upon the principle that the result of the explosion of fired gunpowder produces a pressure upon the walls of the cannon and not a blow. The object of the instrument is to measure the extent of this pressure per square inch. The small specimen here shown with the rifle illustrates its application to heavy cannon. A hole is pierced through the walls of the gun, the area of which is usually one-tenth of a square inch. In prolongation of this hole in the "housing" there slides freely a short rod, provided at its further end with a chisel-shaped knife having a double edge, which is higher in the middle than at the end. This knife rests firmly against a piece of pure copper, where it is held by a screw. When the gun is fired, the pressure of the gas sinks the knife into the copper, and makes a cut. The greater the pressure the longer the cut. The knife is so narrow and so gently convex toward the copper, that a very slight pressure gives commensurable results. The knife and copper are then taken under a lever press, shown in the same building, and the same operation is repeated by means of weights until a cut of the same length as that produced by the gas is obtained. The weight producing this cut is assumed to be equal to that upon the knife in the gun, or equal to one-tenth the maximum pressure per square inch of the gas upon that portion of the walls of the gun. The pressure is obtained to ascertain the strength of cannon and the effects of different powder and projectiles. The pressure gauge here shown is meant to obtain the pressure against the walls and head of the rifle cartridge. A hole is cut through the side of the cartridge communicating with the hole in the housing. (*Vide* General Rodman's experiments on material for cannon and cannon powder.)

No. 12. Rodman's internal pressure gauge for cannon; two sizes.

The same in principal as No. 11, but intended to obviate the necessity of cutting through the walls of the gun. This gauge is thrown into the gun before the powder is inserted, or else is tied up in the bottom of the cartridge, so that the explosion tends rather to keep it in than to throw it out. The gas, being prevented by the copper gas check from getting through on the inner side of the plunger, presses the knife into the copper, as in the former case. Two sizes are here shown, one with an aperture one-tenth square inch, and one with an aperture one one-hundredth square inch. The object of the latter is to reduce the size of the housing to the utmost, as the large gauges interfere somewhat with the inflammation of the charge. (See Rodman's Experiments, p. 299.)

No. 13. Metcalfe's pressure gauges; two sizes.

This is upon the same principle as the Rodman gauge, but mainly designed to be more compact than the other. The knife consists of a spiral edge formed on the surface of a cone. This cone is formed on the end of a piston exposed at its outer end to the gas pressure, by which it is driven into the copper. The greater the pressure the more of a spiral cut results. The spiral cut is measured by the protractor, and by comparison with a table previously prepared gives the pressure obtained. The grooves upon the body of this piston or plunger serve to break the force of the gas, in its efforts to leak past, and obviate the need of a copper cup gas check. The small gauge may be used externally or internally in cannon. The large gauge is intended for internal use. Each gauge is provided with a full complement of tools, spare coppers, &c.

No. 14. Collection of targets showing the accuracy of the Springfield field service rifle, fired from the shoulder at different ranges with service ammunition.

Vide Description Springfield Rifle, p. 29.

No. 15. Diagram.

Showing the result of experiment conducted at the National Armory to determine the influence upon the initial velocity due to—

First. A variation in the weight of the bullet, the length of bore and charge of powder being the same as used in service.

Second. A variation in the weight of the powder, the length of bore and weight of the bullet being the same as used in the service.

Third. A variation in the length of bore, the weight of charge and of bullet being the same as used in service.

Fourth. A variation in length of bore, weight of powder and bullet, to include the combinations giving the maximum velocities in the preceding cases.

The initial velocities are represented in the diagram by curves of various colors, the points of which were determined by taking the mean of five or more shots, measured simultaneously by the Boulengé chronograph and thread velocimeter. The results of these experiments, all of which are shown in the diagram, point to conclusions which justify no change in the length of bore, weight of powder or shot of the present service rifle.

No. 16. Recording shots.

It being unsafe to expose the target, it becomes impossible to keep a record of the shots. To illustrate, however, the method now employed at arsenals for that purpose, a miniature target house is exhibited, showing how an image of the target is reflected by a camera to the surface of a table, where the recorder can observe each shot as it strikes, unexposed to danger. This method effects also a great saving of time, the old method of recording shots necessitating an absolute measurement of each upon the target. The image is thrown at the Frankford Arsenal upon a lithographic diagram of the target to a scale of $\frac{1}{12}$ and these, after use, become part of the "Record Book of Experiments."

No. 17. Military telemeter.

It measures the distance of an adversary by recording in yards the interval which elapses between the flash and report of his fire. It consists of a glass tube graduated to yards and quarters. This tube, closed at each end, is filled with distilled water and alcohol, or with sulphuric ether, through which a silver index, formed of two disks, united by a stem, will move uniformly under the influence of its weight. The tube is protected by a brass case, the graduation and index being exposed through an aperture. A velocity of $\frac{1}{750}$ that of sound has been adopted for the index, so that 1 inch on the scale represents 694½ yards in distance, and is so indicated. To correct for an error due to personal equation, which experience has shown to amount to about 164 feet, this origin is placed at that point instead of at the zero point of the scale. To use the telemeter, it is held between the fingers of the right hand, the arm extended, the aperture toward the body. Turn the wrist to the left until the index reaches the origin and then hold the instrument horizontal. As the flash is observed turn the wrist quickly to the right, and hold the instrument vertical till the report is heard, when the instrument is brought back to the horizontal position, and the scale read as shown by the lower disk of the index.

The two telemeters exhibited are the infantry, for ranges up to 1,650 yards; the field artillery, for ranges up to 3,700 yards.

(*Vide* Ordnance Note No. 28.)

No. 18. Mercurial densimeter.

Is used to determine the specific gravity of gunpowder, which should be about 1.75. It consists of an open vessel containing mercury, and a glass globe joined at top to a graduated glass tube and connected with an air-pump. The globe can be separated from the mercury and air-pump by stop-cocks, and detached for weighing. The instrument depends upon the principle that the specific gravities of mercury and gunpowder are proportional to equal volumes of the same. The globe is filled by means of the air-pump to a certain height on the glass tube, detached and weighed. It is then emptied, cleaned, a certain weight of powder introduced, mercury then pumped to the same height on the tube, and again detached and weighed. The difference between the first and second weights gives a quantity from which the specific gravity is rapidly obtained.

(*Vide* Benton, p. 28.)

H.—Miscellaneous.

No. 1. Model of Rock Island Arsenal. (Scale, $\frac{1}{300}$ inch = 25 feet.)

Produced in photo-sculpture by Baron F. von Egloffstein under the direction of Lieut. Henry Metcalfe, United States Ordnance Corps.

The houses are photographed, the plates exposed over plates of sensitized gelatine, the insoluble light portions washed out, the gelatine film swelled by certain means so as to develop the relief. The face of the house then cast in plaster in the film, each pane of glass, each stone, each joint, appears with absolute exactness.

A heliostat, consisting of a mirror moved by clock work, directs upon the model in an invariable position the rays of the sun, so as to present the model constantly in its best light. The effect is thus independent of the time of day at which the model is viewed. The same principle is applicable to pictures or other works of art requiring a special light for their best effect.

No. 2. Wilderness tree.

Section of an oak, which stood inside intrenchments near Spottsylvania court house and was cut down by musket balls in an attempt to recapture the works previously carried by the Second corps, Army of the Potomac, May 12, 1864.

Presented to the Hon. Secretary of War by Brev. Maj. Gen. N. A. Miles, commanding First Division, Second Corps, Army of the Potomac.

No. 3. "George M. Patchen."

The skin of this once famous trotter is stuffed, and serves to display the harness of the Gatling cavalry cart.

No. 4. Bullets welded together by contact.

Two bullets found at the siege of Petersburg which met in mid-air, point foremost. The forms of the bullets indicate from which side they were fired. The force of contact fused the points, where they are fast together.

REPORT

ON

ORDNANCE, ORDNANCE STORES, MACHINERY, INSTRUMENTS ETC., EXHIBITED AT THE INTERNATIONAL EXHIBITION, 1876, EXCLUSIVE OF THE UNITED STATES GOVERNMENT DISPLAY.

By First-Lieut. HENRY METCALFE, *Ordnance Department.*

The subject-matter of the report is arranged in the eight following classes:

A.—Cannon and carriages.
B.—Cannon ammunition.
C.—Small arms.
D.—Small-arm ammunition.
E.—Equipments, &c.
F.—Machinery.
G.—Instruments.
H.—Miscellaneous.

CLASS A.—CANNON AND CARRIAGES.

AMERICAN STEEL GUN TUBE.

The Midvale Steel-Works, Nicetown, Philadelphia, exhibit a blank (solid) gun tube of steel 11 feet 7½ inches by 12¾ inches diameter, made of Siemens-Martin steel.

The specimen appears solid and altogether a beautiful piece of work. A sample of the metal, tested at the Washington navy-yard, gave the following results:

Limit of elasticity, between 50,700 pounds per square inch and 54,070 pounds per square inch.

Ultimate breaking strain, 83,824 pounds per square inch.

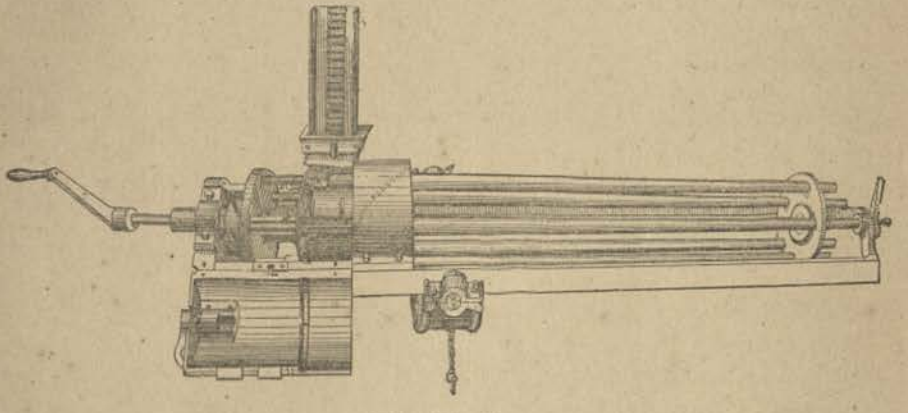
Elongation under strain, 16.5%.

Diameter of section at fracture, reduced 14.25%.

They also exhibit a steel ingot of 7,000 pounds, made by the same process.

BAILEY MITRAILLEUSE.

The Bailey gun is essentially a modification of the Gatling, with these differences: In the Bailey gun the barrels revolve with an independent reciprocating motion, such as is imparted to the locks of the Gatling. The lock of the Bailey gun is single and stationary. The sketch represents the lid covering the working parts of the gun thrown over to the right. The main spindle traverses the horizontal rectangular frame of the gun from front to rear. It is keyed directly to the handle in rear, and also to a series of disks strung along its length. The forward part of the casing carries on its interior surface a spiral rib, which passes in between two short lugs on the butt of each of the barrels, and thus, as the barrels are turned, gives them the reciprocating motion desired. A feather on the butt of each barrel keeps it from turning on its own axis. The barrels are cut away on one side, in rear, for about the length of a



Bailey Mitrailleuse.

cartridge, so as to form a trough. As the barrels in their revolution approach the bottom of the feed case, they pick up the cartridges on this trough. As they go on they slide backward through the second disk from the rear; the abutment bolts, fastened solidly to the first disk, entering the troughs, and passing the cartridges which they contain into the chambers to the front. One of the short spiral ribs on the hub of the first disk has meanwhile engaged with a lug on the hammer-bolt, and pressed it back against a spiral spring surrounding the bolt. When the firing point is reached this lug slips off the rib and allows the bolt to fly forward and strike a firing pin traversing axially the abutment pin before mentioned. This explodes the cartridge. As soon as the firing point is passed the barrel begins to move forward, leaving the empty shell behind caught by the extracting rib, a portion of which is seen in the lid. The notch in the back of the barrel is chamfered, and the extracting rib which enters this chamfer is made of increasing width to accomplish its purpose the more easily. The shell falls directly to the ground as soon as free from the barrel.

The feeding case is peculiar; it consists of an open tin trough, down the middle of which runs a crimped rib of tin between the concave flutes of which the cartridges are held by the spring of the metal. They are fed down by their own weight and stripped off by a pair of flat springs fastened to the inside of the hopper and passing upward under the heads and points of the cartridges. It is proposed to use a continuous belt for feeding; in which case the belt could be filled by a man lying down beneath the gun, inserting cartridges into the vacant spaces as they come around.

The gun is mounted on a yoke swivelled in the head of the carriage.

An oscillator was spoken of but not shown. It was said to consist of a cam upon the shaft near the handle, designed to strike alternately on bumpers on each side of it on the stock, and so to give the necessary lateral deviation.

Manufactured by Winchester Arms Company. Price not known.

GARDNER MITRAILLEUSE.

(William Gardner, Toledo, Ohio.)

In the accompanying drawings, Fig. 1 is a side elevation. Fig. 2 is a side elevation, showing the gun with top of the casing raised. Fig. 3 is

Fig. 1.

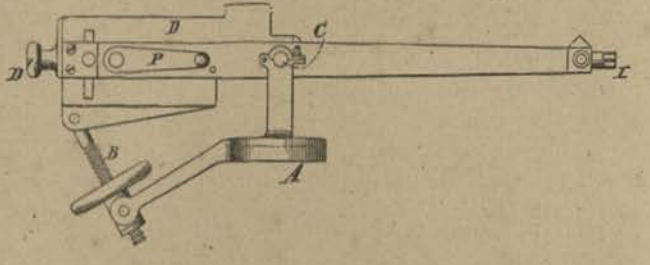
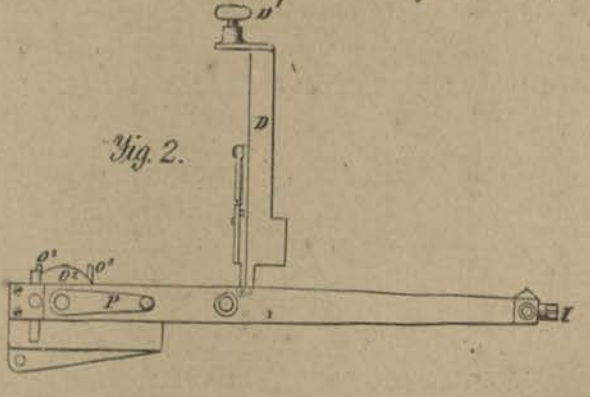


Fig. 2.



a top view, illustrating the use of six barrels in the gun. Fig. 4 is a longitudinal central and vertical section. Fig. 5 is a longitudinal ver-

tical section, showing the lock attached to the mechanism as seen when the top of the casing is removed. Fig. 6 is a plan of the firing mechan-

Fig. 3.

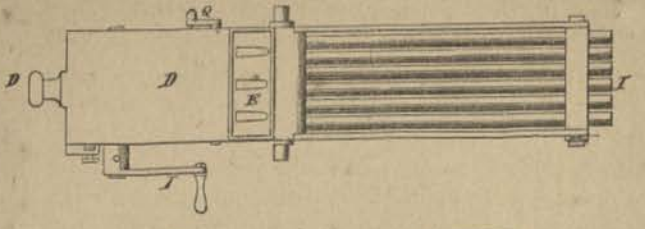


Fig. 4.

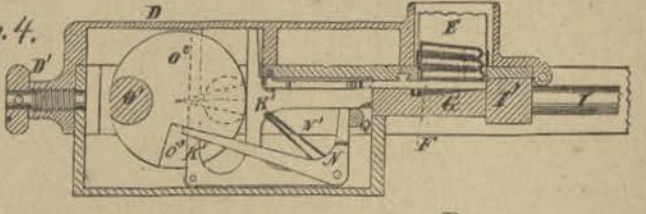


Fig. 5.

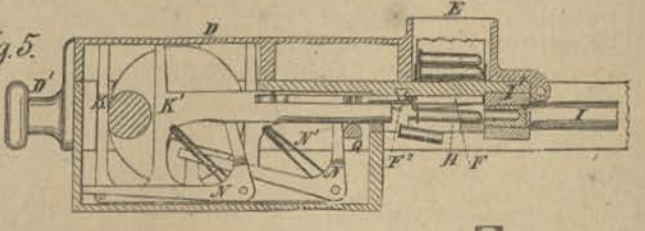


Fig. 6

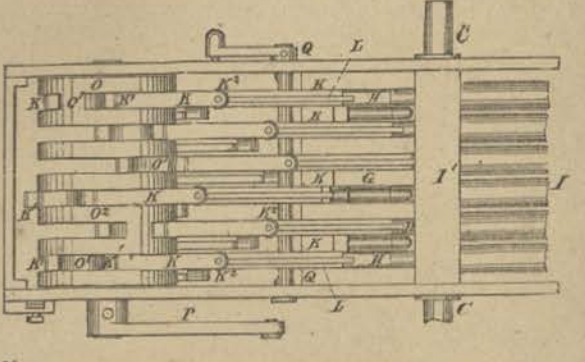
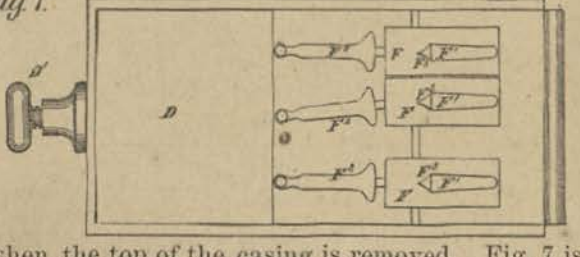


Fig. 7.



ism as seen when the top of the casing is removed. Fig. 7 is a bottom view of the top of the casing. Fig. 8 is an elevation, showing the de-

tails of the construction of the lock. Fig. 9 is a transverse section on the line $x\,x$ of Fig. 10. Fig. 10 is a plan of the grooved block into which the cartridges are fed. Fig. 11 is a plan of the perforated slide and eccentric lever, and an elevation of the same. Fig. 12 is an end view of

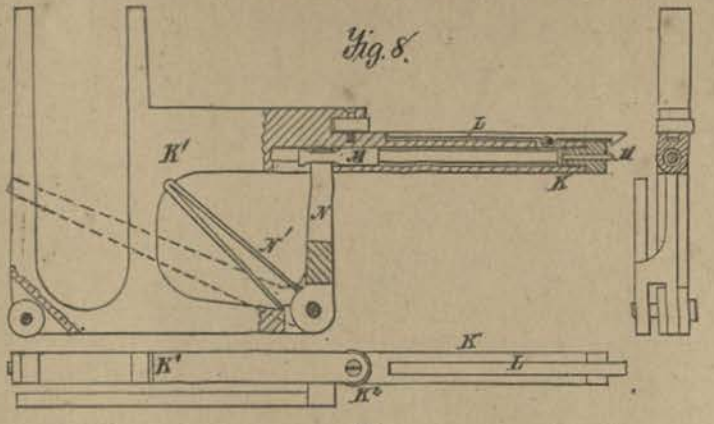


Fig. 8.

Fig. 9.

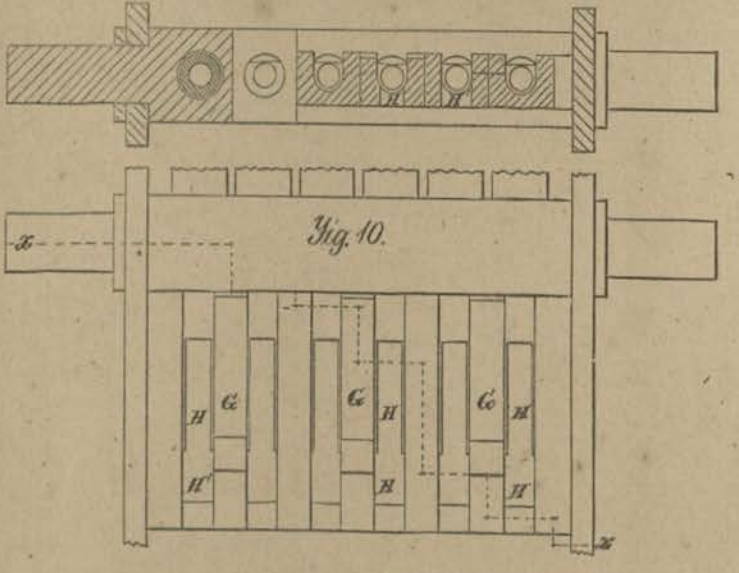


Fig. 10.

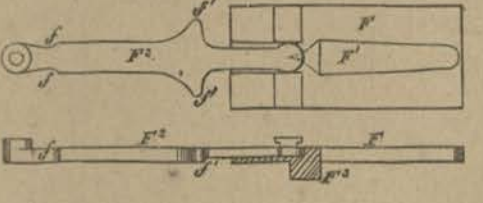
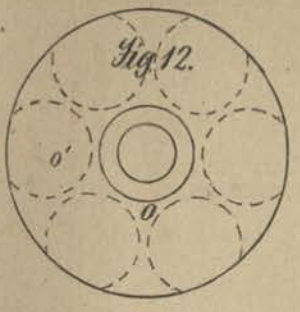


Fig. 11.

the crank and firing-cam. Fig. 13 is an elevation showing the relative position of the notch and crank. Fig. 14 is a front elevation of the same. The same letters are employed in all the figures in the designation of identical parts.

The gun should be constructed with any number of barrels in sets of two. It is illustrated with six; more or less may be employed, but always in even numbers, as it will be more economical to make them



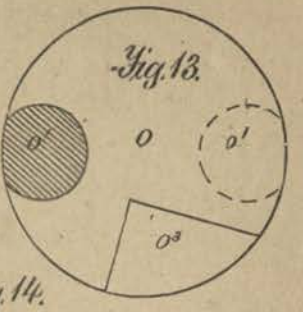
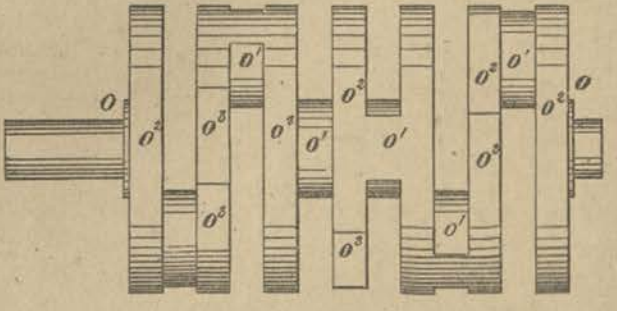


Fig. 14.

work in pairs, though single barrels could be operated. The mechanism for operating a pair of barrels works as follows:

The gun is supported upon the base A, which may be attached to a gun carriage, or to any fixed or movable support. The barrels are placed parallel to one another in a frame, and are adjusted altogether as one piece. The elevation is determined by the screw B, the frame turning upon trunnions, C, and horizontally on a pivot under the center of the base A. The mechanism is inclosed in a tight casing, by which it is protected, the barrels projecting in front of the case. The top D is hinged, so that it may be lifted off, and, when down, is secured by the set-screw D'. The casing is composed of two side pieces, which ex-



tend the entire length of the gun, and support the barrels, near their muzzles, by a cross-piece. They are supported on the cast-block I', which has trunnions turned upon its ends outside the side pieces, and is bored to receive the ends of the barrels, which are screwed into it. By this construction of the frame the parts are perfectly supported and the frame reduced in weight.

The following changes in the mechanism of the gun were adopted after the arrangement for the hopper and cut-off shown in Figs. 1–14 had been adopted and the corresponding sketches had been made. They are given separately so as not to confuse the original description:

Fig. 15 is the feed-slide hinged to the forward end of the top D, so

as to fold down backward when not in use. This sketch as well as that of the rear elevation of the cut-off, Fig 16, is designed for a two-barrel gun, the parts being repeated as often as may be required by the number of barrels used. When standing up the feed-slide is ready to receive two rows of cartridges inserted simultaneously from perforated blocks, the heads of the cartridges being caught by the flanges of the feed-slide before the blocks are withdrawn. The cartridges are thus held by their rims until their own weight feeds them into the mechanism of the gun. The feed-slide is held fast, either up or down, by a spring-pin on the side, the point of which enters one of two notches cut in the nearest hinge-lug. Fig. 15 shows the underside of the top D as

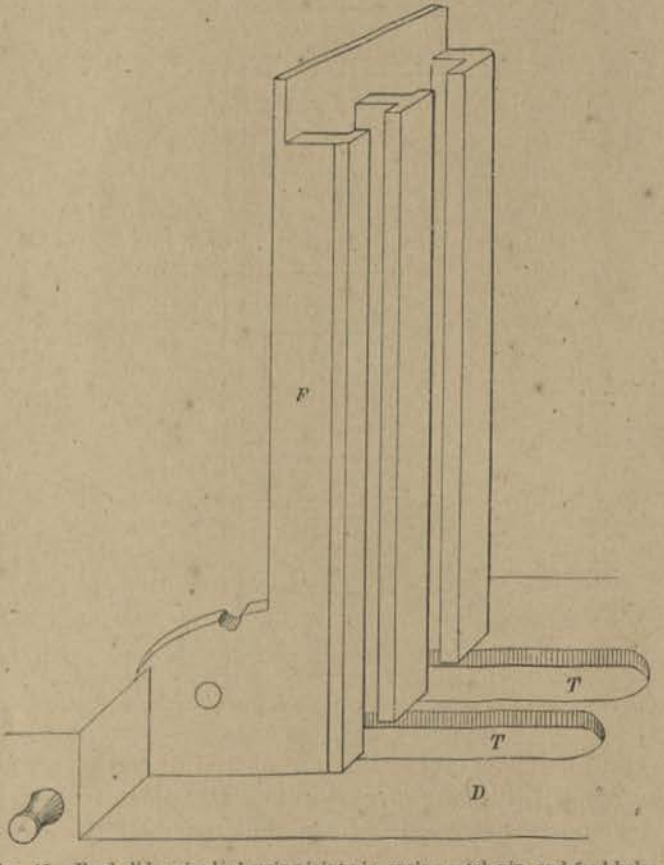


FIG. 15.—Feed-slide raised, showing joint-pin, spring-catch pin, and feed-holes.

now arranged. A A are the shifters pivoted at C C. They are confined by the bar S at their forward ends; they are enlarged and cut through to match the feed-hole T made through the top of D. Ordinarily they are kept off the hole to the right by the pressure of the spring B. This causes them to partly close the hole and prevent the entrance of cartridges from above. About the middle of each shifter is a beveled stud, *b*, flaring outward to the left and rear. The forward motion of the breech-bolt strikes this bevel, and throws the shifter to the

left sufficiently to allow a cartridge to fall through. The cartridge falls on top of the bolt, where it remains until the bolt is drawn back. It then falls upon the plate H, Fig. 5, in front of the bolt, and is pushed forward into the chamber of the barrel at the next advance of the bolt. The form and position of this plate is such that its solid part will receive the point of the cartridge, and the flanged head of the cartridge will be supported upon the parallel sides of the slot, which is not wide enough to permit the head to pass at this point, where it is received when it falls from the feed-slide. But in rear the slot is wider, as shown at H, Figs. 9 and 10, so that at this point the cartridge will fall through. The bevel *b* on the underside of the shifter A shuts across the back of the ante-

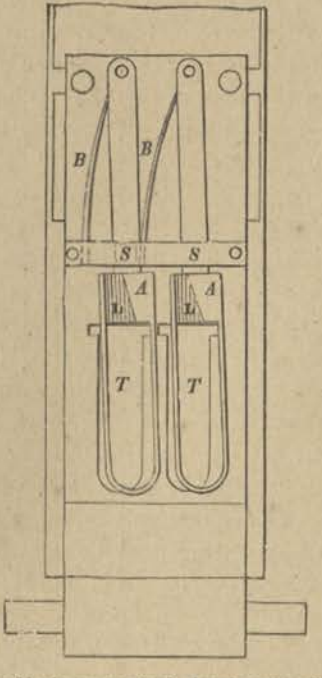


FIG. 16.—Rear elevation of lock-cover raised, showing cut-off springs and feed-holes.

chamber, and prevents the cartridge from sliding back and falling out of the slot when firing at an elevation. It holds it there until the plunger K is pushed forward far enough to prevent the escape of the cartridge, when it is drawn aside to make way for the plunger. The arrangement last described supersedes the plan shown by letters F, F^1, F^2, F^3, Figs. 5, 7, 11.

The gun is fired by the following mechanism: K K, Figs. 6, 8, are the reciprocating plungers, which slide to and from the barrels in the antechamber. Going forward they strike the end of the cartridge lying on plate H, and push it forward into the barrel; when it is pushed home, the notched head of the extractor L engages with the flange on the head of the cartridge. The hammer is then made to strike against the firing-

pin M to discharge the cartridge. The return movement of the plunger draws back the cartridge by the extractor; when the head reaches the wide slot H^1 it falls through the opening to the ground, leaving the antechamber open to receive another cartridge from the feed-slide. Each plunger is actuated by a crank, O^1, connected with a cam-wheel, O^2, notched at O^3, which operates the hammer. The rear end of the plunger is U-formed, as shown at K^1, and embraces the crank O^1. This crank is flattened on one side in such a manner that when that side is in action, which occurs just when the cartridge is pushed home, the crank will communicate no motion to the plunger until the cartridge has been fired. The recoil will be sustained by this flattened portion of the crank.

The hammer is a bell-crank lever, N, the upper end of which is pressed forward by the spring N^1, the long arm resting against the under face of the cam O^2. This holds back the hammer until the long arm falls into the notch O^3, when the spring throws the hammer sharply forward against the rear end of the firing-pin M, driving it against the cartridge. The cams and cranks are rotated by the hand-crank P, or by a belt and pulley.

In order to provide against accidents a flattened shaft, Q, is placed in front of the hammer in such a position that if the part of greatest diameter is placed opposite the hammer it will intercept the blow before it can strike the firing-pin; but if the flattened side is presented next the hammer it will have its full throw against the firing-pin, and fire the cartridge. The end of the hammer enters a slot in the rear end of the firing-pin, which moves in both directions with it through a space determined by the position of the shaft Q. The trunnions C are extensions of a block, I', into which the barrels are screwed at the breech, and it also forms part of the frame and one end of the casing.

The relative arrangement of the cranks and cams determines the order of fire, which may be consecutive, or in volleys of all or part of the barrels employed.

KRUPP FIELD AND MOUNTAIN GUNS.

The following sizes are shown, viz: 8.7-centimeter, field; 7.5-centimeter, field; 8-centimeter, mountain.

The following tables give some of their principal weights and dimensions:

8.7-CENTIMETER (3.42-INCH) FIELD GUN.

Weight of gun with wedge	pounds..	1,069.5
Preponderance on the breech face	do....	101.5
Weight of charged shell	do....	13.69
Weight of bursting charge	do....	6.02
Weight of canister shot	do....	13.6
Weight of charge for gun (coarse-grained powder)	do....	3.3
Caliber	inches..	3.42
Length of gun	do....	82.6
Length of bore	do....	73.8

The gun has twenty-four parallel grooves:		
Width of grooves	inches	0.3
Width of lands	do	0.1
The twist is uniform and has a length of 45 calibers	feet	12.84
Length of line of sight	inches	39.3
Initial velocity of shell	feet	1,558.0
Price, in gold, for gun with spare parts		$891

8.7-*centimeter* (3.42-*inch*) *field-gun carriage.*

The carriage has pressed brackets and cross-joints of cast-steel plates, axles of cast steel, wood wheels with iron tires and naves of bronze. Weight of the carriage, without accessories, —— pounds. Pressure of carriage trail, with gun mounted, 1,124 pounds; and complete accessories on the ground, 231.5 pounds. The elevating screw admits of 24° elevation and 8° inclination. The height is 43.7 inches. Price: Carriage, with implements, $586 gold.

8.7-*centimeter* (3.42-*inch*) *field-gun limber.*

Weight of empty limber	pounds	1,102
Weight of accessories for limber	do	154
Weight of ammunition	do	573
Weight of limber with all accessories	do	1,830
Weight of gun and carriage unloaded	do	3,252
Weight of complete accessories and ammunition	do	771
Weight of gun, complete with accessories	do	4,024
Turning angle		175°
Charge upon leading axle	pounds	1,973
Charge upon trailing axle	do	2,050
Draft charge per horse	do	670

The limber is, excepting wheels and pole, constructed of iron and arranged to take 20 shells, 10 shrapnel shot, 2 canister shot, in all 32 projectiles. Price, with implements, $637 gold.

7.5-CENTIMETER (2.95-INCH) FIELD GUN.

Weight of gun with wedge	pounds	661.5
Preponderence on the breech-face	do	95.9
Weight of charged shell	do	9.2
Weight of bursting charge	ounces	4.75
Weight of exploding charge	do	0.5
Weight of shrapnel shot complete	pounds	9.4
Weight of canister	do	8.6
Weight of charge for gun (coarse-grained powder)	do	2.2
Caliber	inches	2.95
Length of gun	do	78.74
Length of bore	do	70.66
The gun has twenty-four parallel grooves:		
Width of grooves	inches	0.27
Width of lands	do	0.11
The twist is uniform and has a length of 45 calibers	feet	11.07
Length of line of sight	inches	35.04
Initial velocity of shell	feet	1,485
Price, with spare parts, in gold		$767

7.5-centimeter (2.95-inch) field-gun carriage.

The carriage is constructed also of pressed brackets with cross-joints of cast-steel plates, axle of cast steel and wheels similar to those of the 8.7-centimeter gun-carriage. The weight of carriage (without accessories) is 1,014 pounds. Pressure of carriage trail, with gun mounted and complete accessories, on the ground, 225 pounds. The elevating screw admits of 25° elevation and 8° inclination. The height is 43 inches. Price, with implements, in gold, $570.

7.5-centimeter (2.95-inch) field-gun limber.

Weight of empty limber	pounds	1,014
Weight of accessories for limber	do	143
Weight of ammunition	do	452
Weight of limber with all accessories	do	1,609
Weight of gun unloaded	do	2,661
Weight of complete accessories and ammunition	do	624
Weight of gun complete	do	3,285
Turning angle		178°
Charge upon leading axle	pounds	1,746
Charge upon trailing axle	do	1,539
Draft charge per horse	do	546

The limber is of the same construction as that for the 8.7-centimeter gun and arranged to take 24 shells, 12 shrapnel shot, 2 canister shot; in all 38 projectiles. Price, with implements, in gold, $637.

8-CENTIMETER (3.14-INCH) MOUNTAIN GUN.

Weight of gun, with wedge	pounds	227
Preponderance on the breech-face	do	60
Weight of charged shell	do	8.6
Weight of bursting charge	ounces	4.75
Weight of charge for gun	do	14
Caliber	inches	3.14
Length of gun	do	38.3
Length of bore	do	25
The gun has eighteen parallel groves, with	do	0.11
Width of lands	feet	9.84
Length of twist	do	9.84
Initial velocity	do	951
Price, with spare parts, in gold		$355

8-centimeter, 3.14-inch-mountain-gun carriage.

The carriage has pressed brackets with cross-joints of cast steel, axle of cast steel, and wheels of same construction as that for the field gun carriage.

Weight of carriage with wheels, 322 pounds; the elevating screw admits of 18° elevation and 10° inclination. The height is 23.6 inches; weight of pole, 24.25 pounds; the ammunition boxes are constructed of wood with iron bands. Each box contains eight shot, viz, six shells and two canister shot, with the necessary cartridges placed in two cartridge-

boxes, fuzes, and necessary accessories. Weight of empty box, 20.9 pounds; weight of box with accessories, 103.6 pounds.

Price, carriage and implements, gold	$392
Price, limber and implements, gold	502
6-centimeter mountain gun:	
Price, gun and spare parts, gold	346
Price, carriage and implements, gold	378
Price, limber and implements, gold	502

KRUPP 24-CENTIMETER (9.44-INCH) GUN ON COAST CARRIAGE.

Weight of gun	pounds	34,730
Weight of charged steel shell	do	341.7
Weight of common shell with fuze	do	275.6
Weight of charge (prism powder) for steel and chilled-iron shell	do	83.7
The same for common shell with fuze	do	72.7
Caliber	inches	9.44
Length of gun	feet	17.16
Length of bore	do	14.80
Preponderance		0

The gun has fifty-four parrellel grooves, with 4 millimeters width of lands and a uniform twist of 10.8-millimeters in length. Initial velocity of steel shell, 1,542 feet; initial velocity of chilled-iron shell, 1,526 feet; initial velocity of common shell, 1,542 feet.

The gun is mounted on a slide carriage for earth parapets of 6.25 feet height. The carriage has a height of 7.38 feet, and its construction is similar to that for the 35½-centimeter gun, but all its parts are not so heavily constructed and more simple. The limits for elevation are in maximum +20 and —6°. The gun has been subjected, on the end of last year, to a trial at the practice ground at Dulmen belonging to the firm, in presence of a committee of officers of the Royal Dutch Artillery. The following rounds have been fired:

With charges of prism powder and common shells of 275 pounds weight.

66 pounds charge	1
70.5 pounds charge	4
72.7 pounds charge	113
74.9 pounds charge	1
77.1 pounds charge	1
83.8 pounds charge	1

With charges of prism powder and chilled-iron shells of 336.8 to 354.5 pounds weight.

55.1 pounds charge	1
61.6 pounds charge	1
66.1 pounds charge	1
70.5 pounds charge	1
72.7 pounds charge	3
77.1 pounds charge	4
79.2 pounds charge	1
83.8 pounds charge	118
88 pounds charge	2

The prices are as follows, in gold:

Gun, with spare parts	$15,881
Carriage	4,235
Pivoting	817
Implements	294

KRUPP'S 35.5-CENTIMETER (14 INCH ENGL.) GUN NO. 1.

I.—*Description of the ordnance.*

A.—The Gun.

The Krupp 14 inch, breech-loading, rifle cannon, is made of cast steel, banded with endless fiber hoops. The barrel tube is turned down in rear approximately as represented. The breech-piece is then shrunk on it, and the whole inclosed with the outside jacket represented. Longitudinal strength is probably provided for by annular keys, &c. The length of the tube is 26.25 feet, or 2 .5 calibers; length of bore, 22.52 feet, or 19.3 calibers. The twist is uniform and has a length of 52.5 feet, or 45 calibers. The number of grooves is 80; depth, 0.078 inch; breadth, 0.37 inch; breadth of lands 0.18 inch. The gun is fitted with the Krupp solid round-backed wedge for closing the breech, and weighs, including this wedge, 126,500 pounds. The preponderance is 0. The gun is smoothly bronzed, and presents throughout a magnificent specimen of workmanship. The breech is easily opened and closed by one man. The gun, with spare parts, costs at Essen, $69,217 gold.

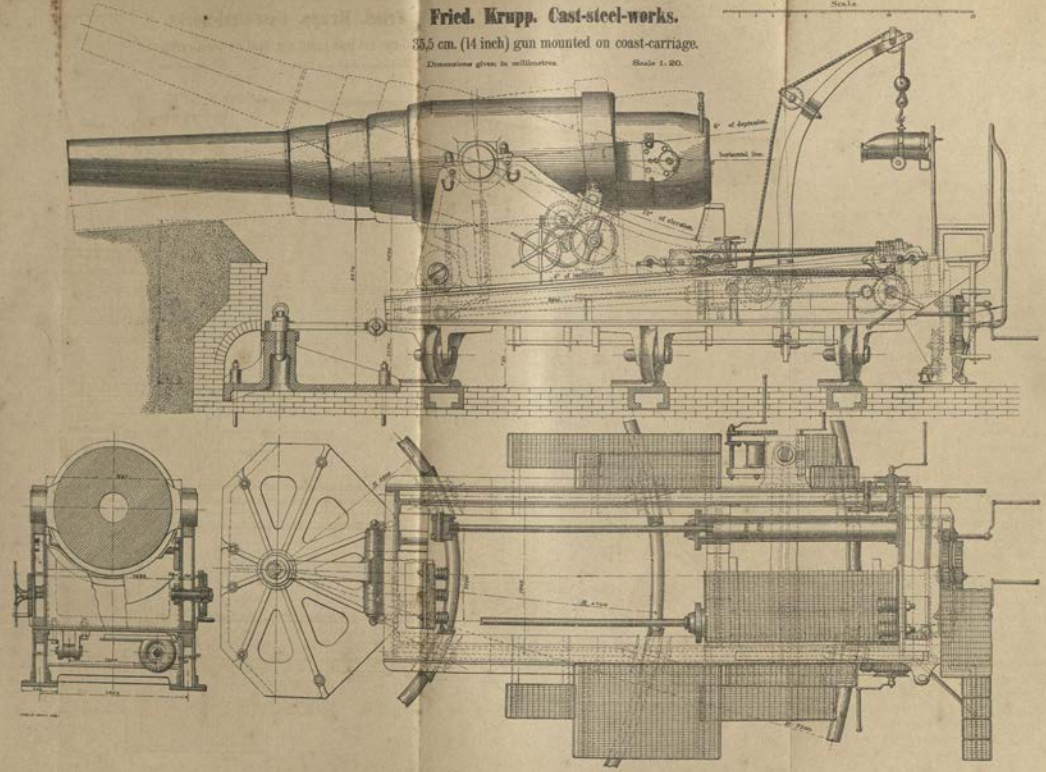
B.—The Carriage.

The carriage and chassis of the 14-inch gun are similar to those used for German sea-coast batteries. The height of trunnions of 8.76 feet allows, with 6° of inclination, firing over a parapet of 6.56 feet height. This carriage corresponds in construction with the Krupp 12-inch sea-coast carriage which was exhibited at Vienna in the year 1873, and which is well known from the description in the Austrian official report of the Exhibition (Volume XLV, General Armaments and Artillery), and in other journals. The differences between them are principally due to the larger caliber of the 14-inch gun. But there are applied some improvements which may still be mentioned. With the elevating apparatus (circular rack) is connected a dial train, so that the gunner working the crank wheel of the elevating apparatus can independently take the elevation. To lay the gun, there is adapted at the rear end of the carriage a horizontal arc, on the platform behind the rear rail, fitted with a pointer on the chassis. These two arrangements allow in a convenient and sure manner sighting during the night and when the weather is not clear. With everything in good order, it requires one man to elevate the gun, four to traverse it, and two to load. The carriage allows 18¾° elevation and 6° depression. To check the recoil there are applied two hydraulic buffers. The weight of the complete carriage (without pivot block and traverse circles) is 74,800 pounds. The top carriage weighs 21,230 pounds.

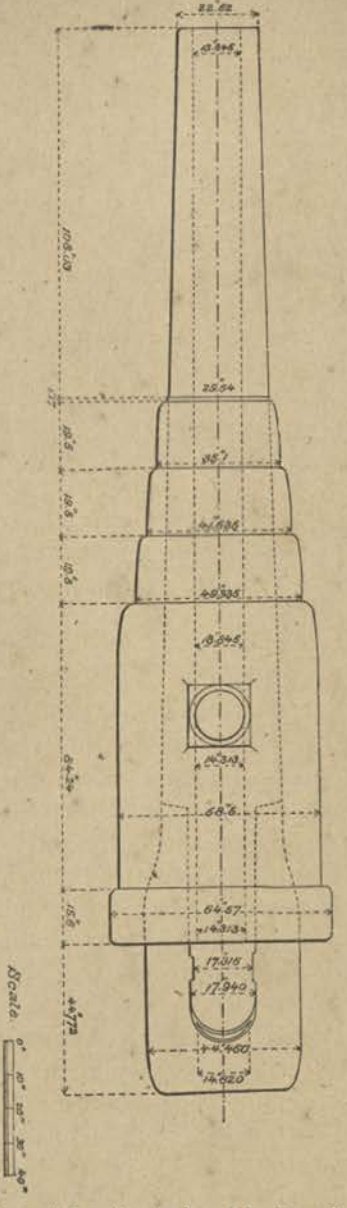
Fried. Krupp. Cast-steel-works.

35,5 cm. (14 inch) gun mounted on coast-carriage.

Dimensions given in millimetres. Scale 1:20.



Each of the cheeks of the top carriage is made of heavy iron plates bolted on a heavy skeleton frame formed of massive rectangular rolled iron beams, bent into the profile of the cheeks of the carriage, as shown by the dotted line. This frame is continuous when finished, but is made



Krupp 35.5 centimeter breech-loading rifle.

up of two pieces, the upper of which is the heavier, bent into shape and then V-welded together. Braces are bolted in between the cheek plates, and to further stiffen these plates, short pieces of gas tube lying in be-

tween the plates are strung on through-bolts, which are riveted firmly on the outside. The frame makes a jog at its lower front corner, to receive the front truck wheels. As ordinarily used, these are mounted on concentric axles; an eccentric device, however, permits them to be set so as to work properly when first applied to the carriage, regulating the amount of clearance necessary on account of the action of the rear truck wheels.

The construction of the chassis is plainly shown in the drawing. It resembles essentially that of the top carriage. The forks are particularly massive. The rear truck wheels run on an inclined plane on the rear end of the chassis rail just after the gun begins to recoil. This tips up the rear end of the upper carriage and causes the front wheels to bear in rolling friction. After firing the gun comes back of its own weight and drops into sliding friction as soon as the rear wheels leave the inclines. The rear wheels are mounted upon an eccentric axle, which can be thrown into gear by means of a vertical worm alongside. This is only done when the carriage is drawn back by hand in mechanical maneuvers by means of the tackle shown at the side. A windlass and crane serve to raise the shot, which can be swung into the loading position by a worm gearing into a toothed collar on the shaft of the crane.

The hydraulic buffer cylinders are made of steel, cast solid and bored out. Spring buffers like those used on railroad carriages are also employed for heurters and counter-heurters. The elevation is given by gearing on the sides of the carriage moved by a hand wheel outside; a dial plate connected with this train of wheels serves as an indicator. When the gun is in position it is clamped by means of a cross-handled nut shown outside. The direction is given by means of a chain passing under two guide pulleys and over a clip drum in rear of the chassis, this drum being turned by gearing driven by hand-power. A small vertical friction roller serves to keep the chain from slipping off the drum. This arrangement is positive and independent of the position of the gun along the chassis. The platform and chassis steps are large and commodious. They are made of wire grating, both for the sake of lightness and to allow the snow to fall through in winter. The material of the carriage is generally of wrought iron. Steel is used for all axles. The gun is provided with cap-squares to allow for jumping; the pintle strap is hinged for a similar reason. The hydraulic buffer pistons are fastened by a strong inclined jointed brace to a heavy web under the top carriage joining the two forward transoms. The cylinder is supported in rear against a heavy compound beam. It is sustained in front by a double transom between the chassis rails.

The carriage alone is said to cost $13,942 gold. The pintle and traverse circles (pivoting), $1,237; the implements, $870; the entire apparatus, $83,000.

C.—AMMUNITION.

Projectiles.

The projectiles consist of steel and chilled blind shells, as well as long (fuze) shells, and are 2.8 calibers long. The rifle motion is imparted in a manner analogous to that of the French Navy projectiles, viz, by two copper rings, of which the foremost is only used for centering, and the rearmost for rotating the projectile.

The weights of the projectiles are given in the following table:

	Weight of projectile without bursting charge.		Weight of bursting charge.		Weight of charged projectile.		Weight of charge.		Initial velocity.	
	Kilograms.	English pounds.	Kilograms.	English pounds.	Kilograms.	English pounds.	Kilograms.	English pounds.	Meters.	English feet.
Steel shell.....	495	1,091.27	15	33.07	510	1,124.5	125	275.6	485	1,591
Chilled shell.....	517	1,140	8	17.64	525	1,157.6	125	275.6	478	1,567
Fuze shell.....	380	838	30	66.15	410	904	110	242.5	495	1,623

This gun is intended to be used with prismatic powder, having only one perforation of 15 millimeters ($\frac{2}{3}$ inch English) diameter, but which in its exterior shape corresponds to the prismatic powder with seven perforations, used hitherto for smaller calibers by Krupp's works, and introduced into Germany, Russia, &c., from the United States. The specific weight of this powder is 1.73 to 1.76. The normal charge was fixed to be 242.5 pounds for steel and chilled shells; 275 pounds for fuze shells, and it was thereby expected that an initial velocity of 1,541.6 feet for chilled shells, 1,558 feet for steel shells, and 1,623 feet for fuze shells would be obtained. The heavy shot are forged solid and then bored out with an expanding tool from the rear.

II.—*Proof trial at Essen, December* 27, 1875.

The trials with this gun and carriage were made at the proof butts belonging to the works. The cast-iron proof projectiles were flat headed, almost cylindrical, and had an average weight of 1,146.6 pounds. The velocities were measured at a distance of 116.4 feet from the muzzle, by a Le Boulengé chronograph after each round. The gas pressure was ascertained by a Rodman apparatus placed in the wedge piece.

Besides the kind of powder above mentioned as suitable for this gun, there were provided for comparison the following kinds of powder, viz:

a. Prismatic powder with seven perforations, density 1.73 to 1.76.

b. Coarse-grained powder of 20 to 25 millimeters ($\frac{3}{4}$ to 1 inch English) size of grain, density 1.73 to 1.76.

γ. Coarse-grained powder of 25 to 30 millimeters (1 to $1\frac{3}{16}$ inches English) size of grain, density 1.73 to 1.76.

The results of the trial are contained in the accompanying table:

The proof was commenced with the prismatic powder with seven perforations, which burnt as anticipated the quickest of the four kinds chosen. The first round with the comparatively small charge of 176.4 pounds showed that this powder, which was advantageously used in the 12-inch gun, acted too rapidly in the 14-inch gun, and would have given, with the normal charge of 275 pounds, a very high pressure without corresponding gain of velocity. Therefore the prismatic powder with one perforation was used at the second round. This answered perfectly. The gas pressure remained even at the increased charges of 286.6 pounds, and 297.7 pounds below the prescribed limit. With the service charge of 275 pounds was obtained a higher initial velocity than was expected, even although allowance is made for the projectiles being 15.4 pounds below the normal weight. A total *vis viva* of the projectile of 20,313 foot-tons at the muzzle was obtained, equivalent to 74 foot-tons per pound of powder, 132 foot-tons per square inch of projectile's cross section, 461 foot-tons per inch of projectile's circumference, and 348 foot-pounds per pound weight of gun. The combustion of this powder was very equal as far as could be ascertained.

Finally, a charge of 297.7 pounds coarse-grained powder, with grains of 25 to 30 millimeters, was used. Notwithstanding that the powder chamber was only 32.6 cubic inches per pound of powder, the powder only burnt very imperfectly; a great part of the powder was blown out of the muzzle unburnt; the velocity of the projectile was very low. Owing to the imperfect combustion of this powder, and also to that of the 20 to 25 millimeters powder, such favorable results as obtained with prismatic powder could not be expected. The proof of this gun was then considered as provisionally finished. It will be hereafter resumed for accuracy at the practice ground at Dülmen, belonging to the works.

The carriage acted without fault during the whole trial, and the manipulation of both gun and carriage was perfectly easy.

An inspection in detail after the trial showed that not the slightest injury had taken place. During the whole trial the bore was not sponged, although ten rounds were fired.

The rifling marks were well grooved on the projectiles which were recovered after trial.

III.—*Comparison with the English* 81-*ton gun.*

The comparison can only be made under the assumption that in both cases the maximum charges are used, the English gun being a proof-gun, in which service charges would not be fired. The figures to be compared are thus the following:

Date.	Gun.	Number of rounds.	Powder charge.			Projectile.		Capacity of powder-chamber.			Velocity of projectile at 32.5 meters (106.6 feet Engl.) from the muzzle.	Vis viva of projectile.				Gas-pressure as taken by the Sebert-Hebler apparatus in kilograms per square centimeter.	Recoil of carriage.	Notes.
			Class of powder.	Weight.	Cartridge. Length. / Diameter.		Class.	Weight.	Length.	Diameter.	Cubic contents. Total. / For 1 kilo. (2.204 lbs. Engl.) powder.		Total. $P \cdot v^2$ / $2g$	Per sq. cm. of Engl.[1] of projectile. $\frac{P \cdot v^2}{2g \cdot f}$	Per square cm. (1 sq. in. Engl.) of projectile. $\frac{P \cdot v^2}{2g \cdot F}$	Per kilo. (2.204 lbs. Engl.) of projectile. $\frac{P \cdot v^2}{2g \cdot Q}$	Per kilo. (2.204 lbs. Engl.) weight of gun.		
				Kilos (lbs. Engl.).	Millimeters (feet Engl.).			Kilos (lbs. Engl.).	Millimeters (feet Engl.).		Cubic centimeters (cubic feet Engl.).	Meters (feet Engl.).	Meter-tons (foot-tons Engl.).			Meter-kilos (foot-lbs. Engl.).		Millimeters (feet Engl.).	
											Chronograph No. 10.								
1875. 16. Dec. 1401.	35.5 cm (14 lbs. Engl.) gun No. 1.																		
	Caliber, 3.202 meters (14 lbs. Engl.).		Prismatic powder, with 1 perforation (0.5 millimeters in diameter).	87 (191.8)	32 layers / 10 perforat.	40 perforat. per layer.	Shot with fuse-wood + shoeing ring and rear centering-ring.	522 (1, 157. 8)	1, 111 (4. 760)	307 (1. 71)	190.97 (6. 742. 39)	0.59 (3.9)	467. 5 (1, 534. 74)	3, 643. 7 (37, 825. 63)	29. 39 (307. 62)	2. 46 (25. 53)	69. 75 (736. 28)	33. 79 (363. 67)	2. 750	3, 400 (4. 79)	Distance between first wire screen and muzzle of gun, 22.1 meters (72 feet Engl.).
	Total length, 8.66 meters (28.25 feet Engl.).																		Distance between wire screens, 20 to 1 mm (40 feet Engl.).
	Length of bore, 6.450 + 0.610 meters (21.1 + 2 feet Engl.).	2	The usual with one perforation of 10 millimeters (0.4 inch Engl.).	88 (194. 0)	42 layers / 10 perforat.			524 (1, 159. 6)	1, 108 (4. 36)	307 (1. 71)	190. 1 (6. 710. 9)	0. 59 (1. 93)	463. 4 (1, 520. 6)	3, 559. 8 (37, 106. 14)	29. 87 (308. 68)	2. 41 (25. 13)	68. 08 (709. 8)	33. 18 (345. 7)	2. 850	3, 190 (4. 14)	Weather-screened, heavy fog. Scarcely visible.
	Length of rifled part, 4.331 meters (14.24 feet Engl.).	3	Prismatic powder, weighing 0.36 kilo. (0.8 lbs. Engl.).	88 (194. 0)	47 layers / 10 perforat.			520. 5 (1, 147. 5)	1, 099 (4. 41)	307 (1. 71)	191. 8 (6. 772. 3)	0. 59 (1. 93)	456. 8 (1, 498. 28)	3, 500. 1 (37, 161. 3)	28. 85 (312. 53)	2. 38 (27. 18)	66. 45 (734. 39)	32. 53 (362. 56)	2. 750	3, 020 (3. 549)	Wind S/W.
	Diameter of bore in the oblique, 0.350 meters (1.17 feet Engl.).	4		88 (194. 0)	52 layers / 10 perforat.			524. 5 (1, 155. 7)	1, 109 (4. 36)	307 (1. 71)	190. 3 (6. 717. 2)	0. 59 (1. 93)	468. 4 (1, 537. 42)	3, 610. 9 (38, 712. 9)	30. 30 (321. 5)	2. 49 (26. 69)	68. 97 (735. 34)	37. 69 (761. 71)	?	3, 400 (3. 51)	Thermometer + 3° R.
	The same in powder-chamber, 0.597 meters (1.3 feet Engl.).																		Barometer, 26" 2". A.
	Number of riflings, 80.																		
	Length of twist, 18 millimeters (2 in. Engl.).	5		87 (191. 8)	32 layers + 24 in / 10 perforat.			521. 5 (1, 153. 1)	1, 103 (4. 34)				472. 7 (1, 550. 39)						2, 750	3, 710 (4. 656)	
	Weight of gun, including wedge, 57, 500 kilos (126.8 tons Engl.).	6						527. 4 (1, 160. 8)	1, 105 (4. 35)				475. 2 (1, 558. 66)						2, 700	3, 700 (4. 772)	
		7						524. 5 (1, 155. 1)	1, 109 (4. 37)				472. 7 (1, 550. 39)						2, 600	3, 710 (4. 660)	
		Mean.						524. 3 (1, 154. 8)	1, 107 (4. 36)	307 (1. 71)	191 (6. 764. 7)	0. 59 (1. 9)	471. 8 (1, 546. 97)	3, 573. 6 (38, 085. 67)	29. 98 (319. 69)	2. 44 (25. 94)	67. 91 (723. 7)	336. 8 (751. 196)	2. 733		
		8		88 (194. 0)	36 layers.			526 (1, 158. 8)	1, 108 (4. 37)	307 (1. 72)	190. 5 (6. 676. 34)	0. 59 (1. 94)	468. 4 (1, 536. 76)	3, 559. 4 (38, 711. 3)	29. 77 (316. 71)	2. 44 (25. 73)	67. 85 (723. 36)	336. 5 (762. 78)	2. 800	3, 720 (4. 694)	
		9		87 (191. 8)	38 layers. 8 perforat.			526 (1, 160. 6)	1, 109 (4. 37)	307 (1. 21)	191. 4 (6. 754. 76)	0. 59 (1. 93)	467. 1 (1, 532. 42)	3, 548. 6 (38, 615. 3)	28. 73 (306. 9)	2. 41 (25. 73)	68. 55 (730. 78)	335. 8 (761. 57)	2. 850	3, 720 (4. 67)	
		10	Coarse-grained powder, 1 perforation of 25-30 millimeters, size of grain 1.75-1.76 density.	88 (194. 0)	3, 200 / 10. 5	256 to 260 / 11. 5 to 11. 583		524. 5 (1, 155. 1)	1, 111 (4. 38)	307 (1. 21)	191. 4 (6. 757. 98)	0. 59 (2. 04)	467. 1 (1, 532. 42)	3, 558. 5 (38, 716. 38)	29. 83 (317. 66)	2. 45 (26. 23)	68. 07 (725. 19)	32. 42 (345. 38)	2. 850	3, 810 (5. 176)	A large quantity of powder blown unburnt out at the muzzle.

Face page 790.

[Centimeter = ⅜ inches English. Kilogram = 2205 pounds English.]

Gun.	Weight of gun in kilograms and English tons.	Weight of projectile in kilograms and English pounds.	Weight of charge in kilograms and English pounds.	Initial velocity of projectile in meters and English feet.	Vis viva of projectile in meter tons and English foot tons.			
					Total.	Per centimeter of circumference.	Per square centimeter section.	Per kilograms weight of gun.
English 81 tons	{ 83,060 / (81.7)	571.5 (1,260.2)	* 104.3 * (230)	470 (1541.6	6,450 (21,478.5)	55.7 (185.5)	6.05 (20.15)	0.078 (0.26)
Krupp's 35½-centimeter (14-inch English) gun	{ 57,500 (56.6)	520 (1,146.6)	† 133 † (297.7)	500 (1,640)	6,625 (22,061.3)	59.2 (197.1	6.75 (22.48)	0.115 (0.383)

* 1.7 inches cubes.
† Prismatic powder with one perforation.

The weight of the Krupp gun is consequently only about two-thirds of the weight of the English gun. In the total *vis viva* of the projectile the Krupp gun leads by about 2½ per cent.; in the *vis viva* per centimeter circumference about 6 per cent.; per square centimeter of section of projectile about 11½ per cent. The material of the Krupp gun gives, therefore, about one and a half times as much power as the material of the English gun.

IV.—*Efficiency of the 35½-centimeter (14 inch English) gun against armor plates.*

The *vis viva* of the projectiles with the service charge of 125 kilograms (275 pounds), different ranges, are as follows:

[Charge of powder, 125 kilograms (275.6 pounds). Weight of projectile, 529 kilograms (1,146.6 pounds).]

Range.		Terminal velocity.		Vis viva of projectile.			
				Total.		Per centimeter (⅜ inch English) circumference.	
Meters.	Feet, English.	Meters.	Feet, English.	Meter tons.	Foot tons.	Meter tons.	Foot tons.
400	1,312	456	1,495.7	5,510	18,348	49.5	164.8
800	2,624	440	1,443.2	5,130	17,083	46.0	153.2
1,200	3,936	426	1,397.25	4,805	16,000.6	43.1	143.5
1,600	5,248	414	1,357.9	4,540	15,118	40.6	135.2
2,000	6,560	403	1,321.8	4,305	14,335.6	38.6	128.5
2,400	7,872	392.5	1,287.4	4,080	13,586.5	36.6	121.9
2,800	9,184	383	1,256.25	3,890	12,953.7	34.9	116.2
3,200	10,496	374.5	1,228.4	3,720	12,387.6	33.4	111.2

Against this the principal systems of armor-plated construction require for penetration the *vis viva* per centimeter circumference of projectile, as given in the following table, derived from English data. (*Vide* Engineering, 15, 75.) It is assumed that the Inflexible has double the power of resistance to the Devastation, which estimate will be rather too high than too low.

The last column of the table gives the range at which the respective vessels would be penetrated by the Krupp 35½-centimeter (14 inches English) gun under the supposition that the part of the vessel struck by the projectile is at right angles to the projectile.

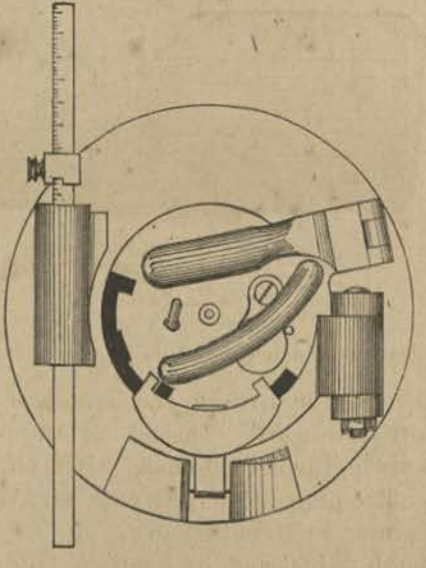
Type of iron-clad vessel.	Necessary vis viva of projectile per centimeter circumference for penetration.		Range of penetration of the Krupp 35½-centimeter (14 inches English) gun.
	Meter tons.	Foot tons.	
Hercules	17.8	59,274	At all fighting ranges.
Devastation	19.9	66,267	
Glatton, Devastation turret	24.1	80,253	
Inflexible	39.8	132,534	At 1,800 meters (5,904 feet, English).

It will therefore be seen from this table that the most powerful iron-clad vessels can be penetrated at a distance of 1,800 meters (5,904 feet Engl.); and that all the other iron-clads could offer no resistance to this gun even at the longest ranges.

With the exception of some of the explanations of the drawings of the gun and carriage above given, the greater part of the above data is derived from a very full and complete pamphlet published by Mr. Krupp, and is given as such without comment.

THE SPANISH BREECH-LOADING MOUNTAIN HOWITZER.

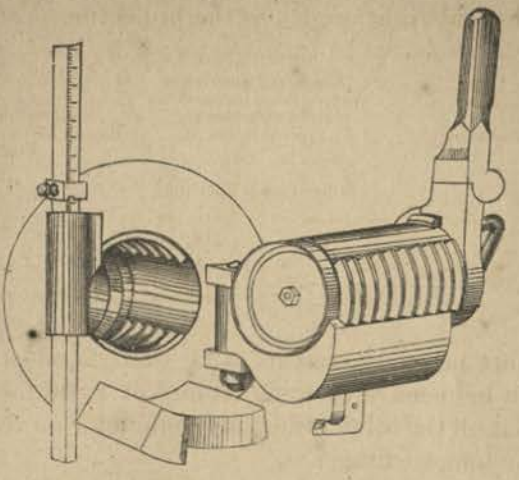
By turning up the hinged hand lever the breech plug is given a quarter turn, liberating the threads of the sectional screw from their engage-



Breech.—Rear view, closed.

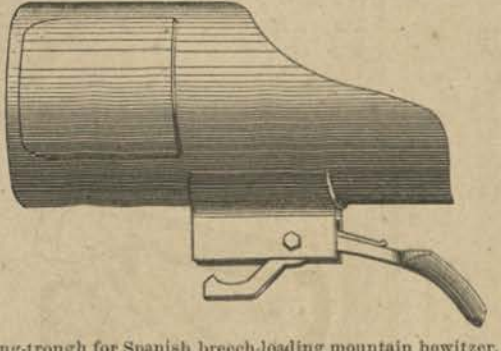
ment with similar threads within the breech. The plug may then be drawn back by the handle in rear and swung to the right, exposing the

chamber. The head of an L-shaped spring lever pivoted to a horizontal axis in the slide, and having its upper end traveling in a straight groove in the bottom of the plug, rides over a high point near the for-



Breech. Rear view open.

ward end of this groove, and lying in a sort of recess so formed keeps the plug from sliding accidentally when open, otherwise it might give trouble in shutting from the sliding forward of the plug before the hinge begins to turn. When the slide is swung around to close the piece, the horizontal arm of this lever strikes a beveled surface formed in a lip projecting from beneath the breech, and turns it so that its upper end will descend out of its recess and allow the plug to move forward freely



Loading-trough for Spanish breech-loading mountain howitzer.

on the slide. It is locked by turning the hand lever to the right, folding the handle down afterward. The face of the plug is separate, revolving upon an axis in the breech-block. It is cupped out in front to form a gas check. The plug is pierced with an axial vent. The plug moves on the slide in an undercut groove.

The loading trough is inserted by hand to guide the shot over the screw threads in the breech. It is locked by a spring catch like that on the slide, but running out to form a handle in rear, by which it may be detached and removed. The V-shaped notch in the piece is to help

guide the trough in place. It is assisted by the projections on each side of the trough.

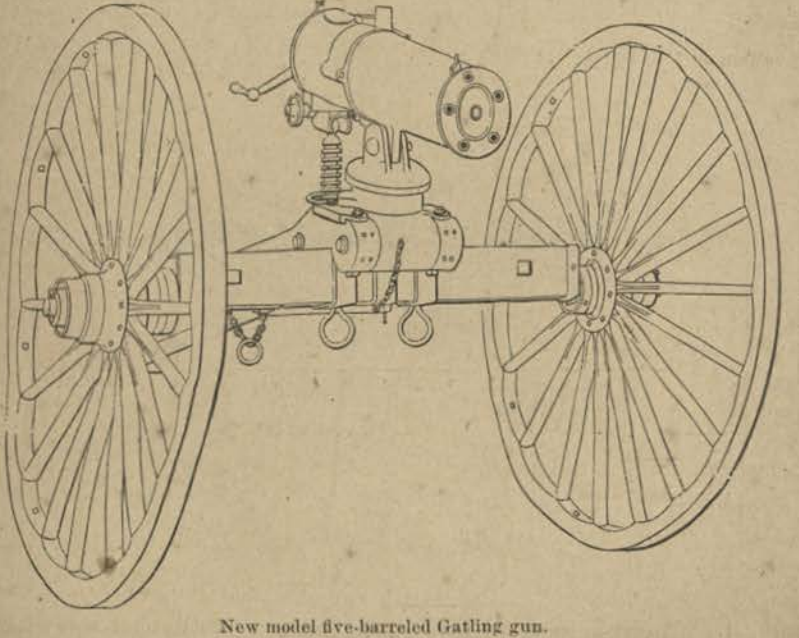
NEW MODEL FIVE-BARRELED GATLING GUN.

The Gatling Gun Company, of Hartford, Conn., exhibit a specimen of their short-barrel camel gun, weighing 97 pounds, and capable of firing 800 to 1,000 shots per minute, which is distinguished for the following principal changes from the old model:

1st. For lightness, the number of the barrels is reduced to five. These are protected by a brass sleeve covering their whole length, and in which they rotate upon a cap closing the forward end of the sleeve, and upon the rear barrel-plate in the usual position. This cap is mortised through to receive the ends of the barrel. The cylinder covering the locks also envelopes the gun more completely on its under side, preventing the entrance of dust, &c. The under side of this sleeve is formed into a loop by which the gun is held like a carronade.

2d. The side handle is replaced by one directly in rear and attached to the main axis of revolution. This allows the gearing of the former model to be dispensed with, and this much additional space and weight to be gained. The cascabel plate also takes the place of the former diaphragm.

3d. Upon the rear end of the main shaft is an adjustment nut by which the cartridge-head space can be instantly regulated, saving the exposure and loss of time of the former method.



New model five-barreled Gatling gun.

4th. The space in rear of the barrels is so short that the locks can be easily removed by hand, through a hole in the cascabel plate, closed by a simple flat disk.

5th. The hopper is placed directly over the highest point of the cartridge carrier; this causes the entering cartridge to fall more *with* the revolution of the cylinder, and diminishes the chances of its jumping back and clogging. This improvement is said to have very considerably augmented the rapidity of fire. The rearmost half of the fence about the mouth of the hopper is cut away to facilitate the insertion of the feed case.

6th. The new oscillator is shown in the sketch. Its action depends upon the natural lateral swinging motion imparted to the gun as a whole by the operation of turning the crank. The two sliding nuts A B (Fig. 1) travel in grooves within the hollow training screw C, upon

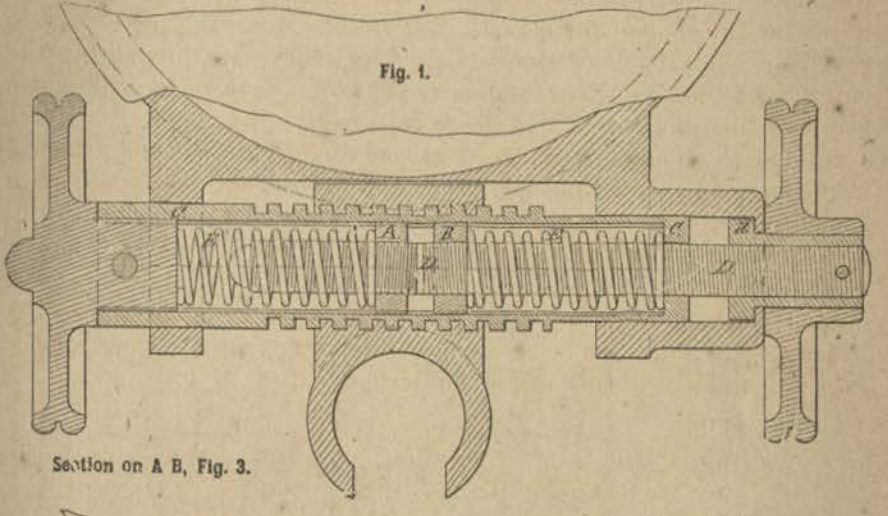


Fig. 1.

Section on A B, Fig. 3.

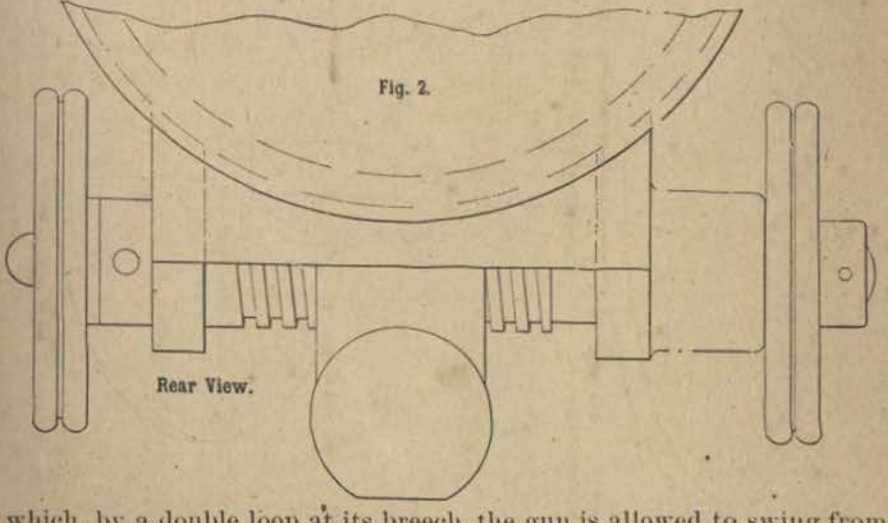


Fig. 2.

Rear View.

which, by a double loop at its breech, the gun is allowed to swing from side to side. A shaft, D, cut with a right and left hand screw-thread to match the nuts A B, passes through them, and by means of a shoulder, *a*, connects the system with the body of the gun. When, by turning

the milled head of D, the nuts are brought to the ends of the bore of C, the gun is locked fast, and no movement is allowed. When they are brought together at the middle point of the bore the gun can swing on each side to an extent determined by the space between each nut and the nearest end of the bore. The springs E E are inserted to deaden

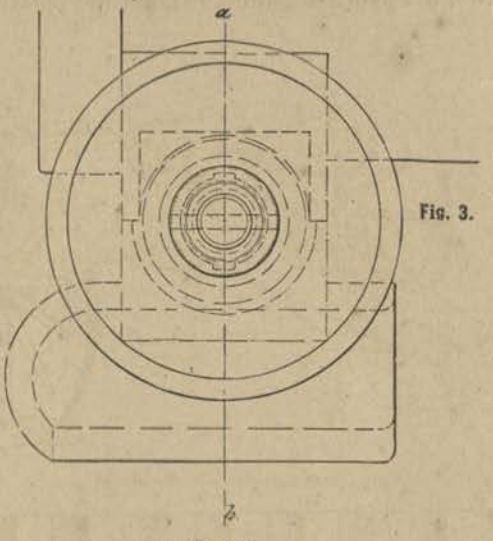


Fig. 3.

Side View.

the shock and to gain the advantage of the rebound. This apparatus works very well. The training screw C, by means of the nutted head on its left, varies the general direction of the piece.

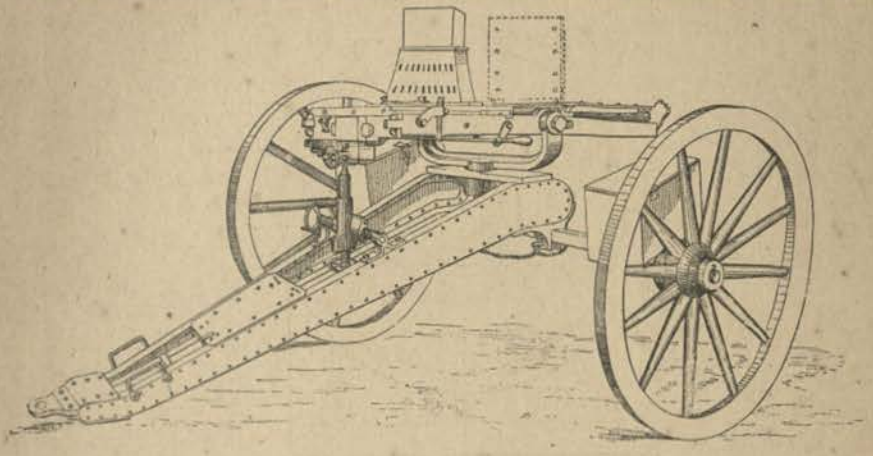
The arrangement of the parts is such that the gun can be taken apart, and assembled with great facility, no tools being required for this except an ordinary screw-driver, punch, hammer, &c.

PALMCRANTZ (SWEDISH) MITRAILLEUSE.

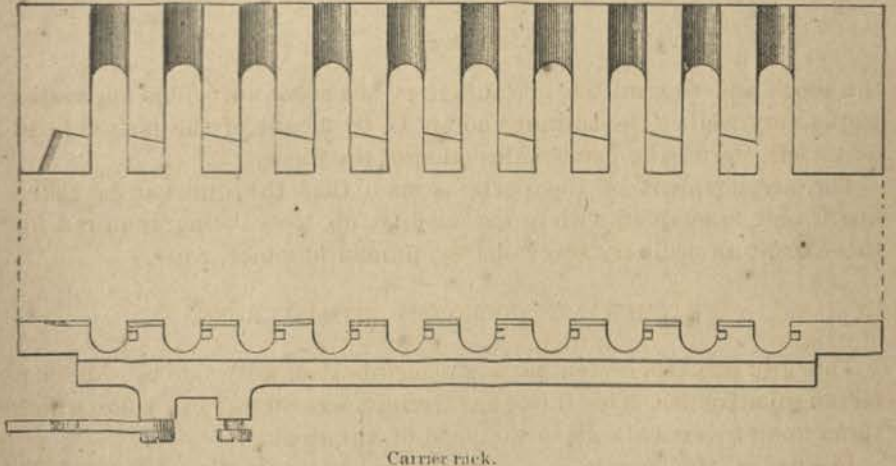
This gun consists of ten barrels placed horizontally side by side in a rectangular frame. This frame has trunnions revolving in a yoke, which turns upon a vertical axis in the head of the stock.

In rear of the barrels is a rectangular box containing the mechanism. Underneath this projects to the right a horizontal hand lever. Just in rear of and above the butts of the barrels is placed a movable trapezoidal feed-case, divided into ten vertical compartments holding fifteen cartridges each. Above it may be placed a second feed-case, the contents of which can be passed into the lower case at pleasure by withdrawing a slide. The lower case has slits in the side, by which the feed of the cartridges which it contains may be regulated by means of a pick wire. The compartments in the lower feed-case diverge so as to bring their lower openings over the barrels; their upper ends are close together, so as to diminish as far as possible the size of the upper case

which fits over them. Immediately in rear of the butts of the barrels is a horizontal comb or carrier rack a little wider than the length of a cartridge, the teeth pointing to the rear. It is permitted a slight reciprocal transverse motion, so arranged that in one position ten horizontal grooves shall lie in the prolongation of the barrels and under the compartments of the feed-case; and in the other position, so that the



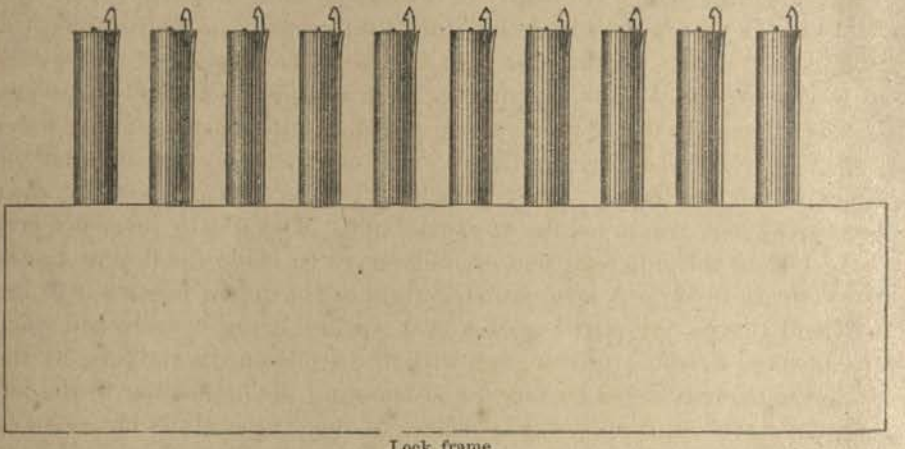
Palmcrantz mitrailleuse—(Swedish.)



Carrier rack.

partitions between these grooves shall occupy the space in rear of the barrels and close the mouths of the compartments in the feed-case. Back of this again is the lock frame. This is a solid plate of metal with a downward lip in front, sliding on the side bars of the barrel frame. From the front of this project ten pistons, by which the cartridges, after falling into the grooves of the rack, are pushed into the chambers and afterwards withdrawn by spring extractors in the sides of the pistons. This lock frame is given a longitudinal reciprocating movement by means of a hand lever. Within the

pistons are strikers and spiral springs. These strikers are provided on their under surfaces with lugs beveled on one side, projecting through longitudinal slits in the under side of the lock frame. Immediately in rear of and below the rearmost position of the lock-plate is a horizontal detent bar with ten flat studs upon its upper surface, beveled sideways. When the hand lever is drawn back the studs on the strikers engage with the detent studs and retain the strikers against the compression of



Lock frame.

the spiral springs during the next forward motion of the lock frame. As the lock frame goes forward the pistons in front push into their chambers the ten cartridges which have fallen from the feed case above into the grooves formed between the teeth of the rack. Just as the cartridges have entered the chamber the detent bar is moved to the left by the continued action of the hand lever. Now, if the ten detent studs were regularly spaced all ten springs would be released at once, and the resulting explosion would be simultaneous, causing considerable recoil. But the detent studs are irregularly spaced so that the fire is consecutive, running in succession from left to right. When the lever is next drawn back the extractors on the sides of the pistons withdraw the corresponding cartridges from the chambers into the grooves through the rack, drawing the heads of the cartridges a little to the rear of the back of the rack. This brings the empty cartridge shells over a wide slot in the groove. This slot is long enough to allow an empty shell to fall through when the head is drawn out of it by the extractor, but not long enough to permit a loaded one to pass in falling upon it from the feed-case. At the moment that the face of the piston is free from the groove in the rack, a lever underneath, which is connected with the hand lever, throws the rack sharply to the left, detaching the shells from the extractor hooks and causing them to fall through the slots to the ground. This same movement brings the intermediate partitions beneath the mouths of the feed-case compartments and cuts off the further supply of cartridges from above. At the next forward

movement of the hand lever the rack is moved back again to its former position, allowing the cartridges just resting upon it to roll into the grooves between the partitions ready to be passed into the chambers at the next advance of the lock-frame with its projecting pistons. An adjustable cam beneath can be set so that the movement of the lever causes a lateral oscillation of the entire frame and barrels. The hand lever moves four separate horizontal levers beneath the lock frame. One of these stretches forward nearly to the barrels and works the rack. The next causes the lock-frame to advance and retreat. A third, upon the same shaft, enters an annular cam beneath the lock-frame and serves to work horizontal bolts, passing through its sides. These bolts, when the lock frame is found in the firing position, enter corresponding holes in the side bars of the gun-frame and sustain the system against the shock of the discharge. They are withdrawn by the motion of the lever before the lock-frame begins to move back. The fourth lever projects in rear from the common center and serves to move the detent bar to the right in firing. A spring on the right of the detent presses it to the left, and serves the purpose of a sear spring, being compressed when the beveled detent studs engage with the studs on the strikers, by the action of their beveled surfaces, and shooting the detent bar to the left as soon as the square forward surfaces of the striker studs have passed the square rear faces of the detent studs. The extractor is pivoted near the head of the piston upon a vertical axis. Its pivot is *within* the point of resistance by the cartridge rim, so that the harder the cartridge pulls the more tightly it is held. The extractor is kept pressed in by an independent flat spring on the side. A folding iron shield, jointed to the side bars of the frame, can be raised to protect the gunner in action.

The lid of the tool box between the sides of the trail can be raised to form a seat for the gunner; upon this he sits, working the lever with his right hand, and replacing the empty feed-cases by filled ones with his left. Two small boxes on the axle carry a supply of feed-cases holding one hundred cartridges each. It usually requires two men to work the gun. With this aid eight hundred shots per minute have been fired. No provision is apparently made to prevent the clogging of the gun in case of a burst head, failure to extract, or other accident to a single lock or barrel, except by reversing the movement of the lever in closing and thus moving the extractor back after it catches hold of any cartridge whose entrance into the chamber is obstructed. This cartridge is withdrawn and dropped. The other cartridges remain upon the carrier rack ahead of their respective extractors, not affording them sufficient resistance to be seized. When the hand lever is next moved forward they are passed into their chambers. The advantages claimed for the gun depend principally upon the seated position of the gunner in firing and the simplicity and strength of the mechanism. The disadvantages are naturally those connected with extended sliding surfaces, and with the reciprocating motion of heavy parts by which the inertia has to be over-

come at every stroke. The gun alone, musket caliber, weighs 750 pounds. With limber and four thousand cartridges, one distribution and twenty-seven feed-cases, it weighs about 1,350 pounds. The gun measures about 50 by 15 by 6 inches deep. It has been extensively experimented with by various European countries, particularly the English and Spanish, and has been adopted to the extent of eighty-four pieces by the Swedish Government.

KRUPP'S PANZER-KANON OR MUZZLING PIVOTING NON-RECOIL GUN.

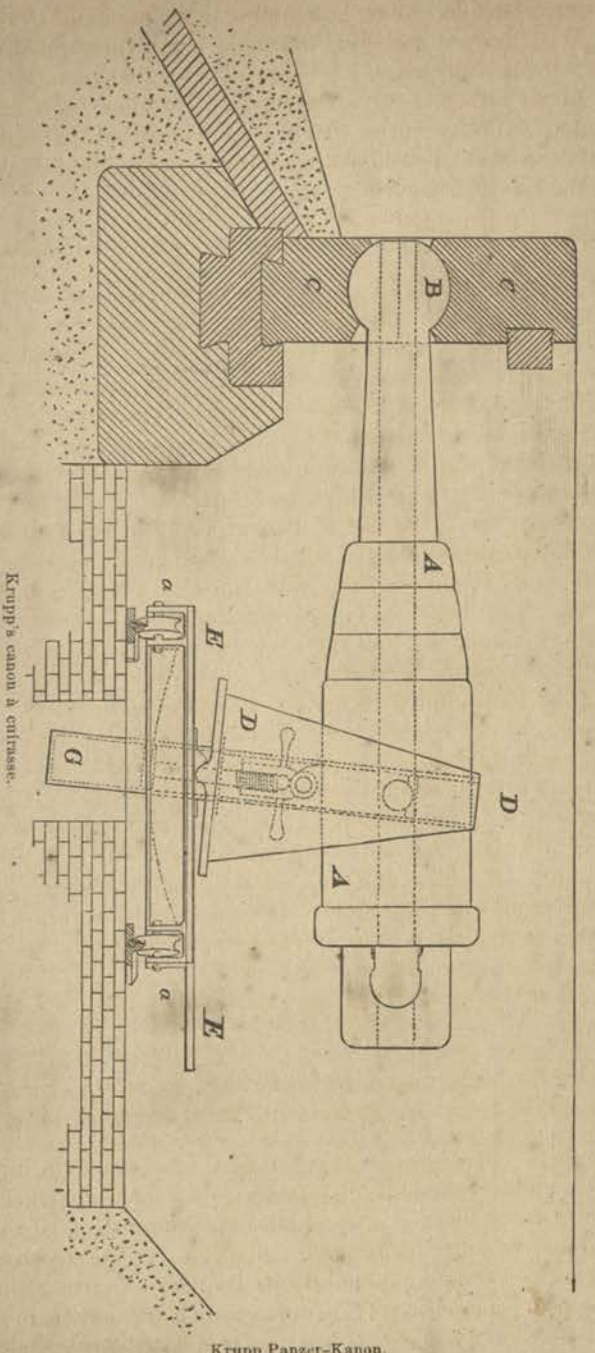
This consists essentially of a large spherical mass of about 2½ calibers diameter formed upon the muzzle of a casemate gun. In combination with this is provided a spherical recess in the iron wall behind which the gun is placed. A section of such a wall shows a more or less solid system of plates, say 5 feet thick for a 12-inch rifle, securely locked and bolted together, and braced by direct and diagonal braces to floor beam connected with the wall. The embrasure is necessarily equally divided by a horizontal joint, within which the gun lies. The fit has to be absolute to prevent battering in the discharge. The advantages of the system proposed are evident: (1.) The absence of recoil, permitting greater simplicity in the carriage and the use of large guns within a limited space. (2.) The complete obturation of the embrasure.

The carriage is shown in the sketch. The trunnions, which may be much smaller than usual, are supported upon slides moved by a screw by hand or by hydraulic pressure or air in the cylinder G. The top carriage rocks on the chassis E, by which the lateral direction can be obtained. Sighting is effected either through the bore or by prolonged artificial sights attached to the exterior of the gun. The system is evidently confined to breech-loaders. It is proposed to apply this principle in three ways: (1.) Behind a fixed straight wall. (2.) Within a movable turret. (3.) The gun and shield on a revolving chassis behind a second semi-circular shield with a horizontal embrasure. It is also proposed to apply it to vessels and to guns already mounted, by providing sufficiently solid buttresses.

It is said that the system has been tried on a 6-inch rifle with satisfactory results.

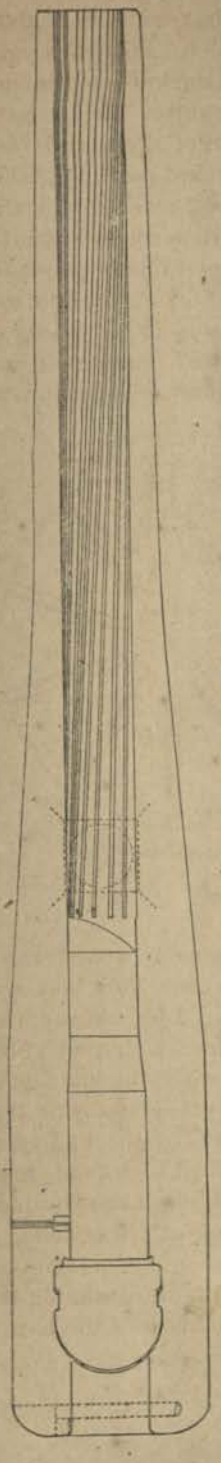
RUSSIAN BRONZE BREECH-LOADING 3.5 INCHES (4-POUNDER) RIFLE, KRUPP SYSTEM, ON CARRIAGE, WITH CORK BUFFER.

The gun itself is of compressed bronze, Lavroff system. It has a solid sliding steel round-backed wedge, fastened by a locking screw, and directly withdrawn by hand. It is cylindrical throughout the breech, and surmounted by two cones of different obliquity. It is rifled with eight grooves 0.9 inch wide and .03 inch deep; the lands are 0.4 inches wide. The twist appears increasing. The fermeture has one feature which is found in all Russian guns of this system, viz, a small bar of steel sliding



Krupp's canon à cuirasse.

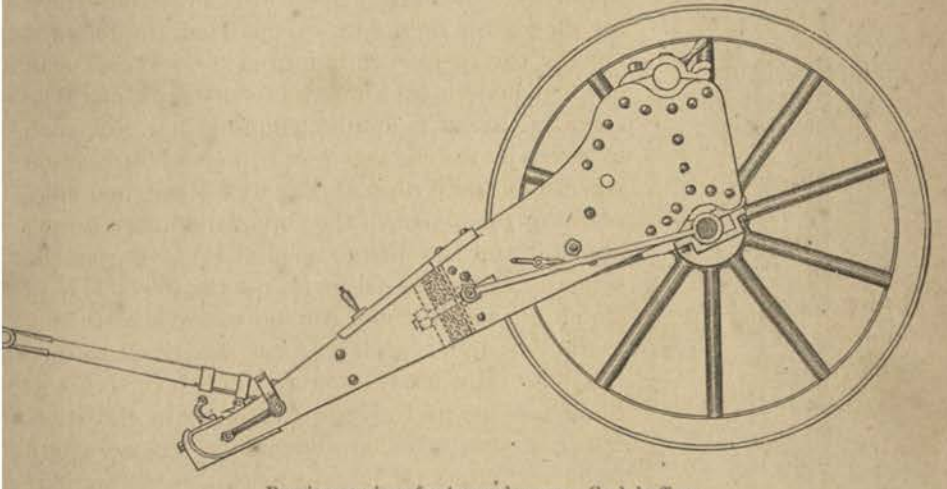
Krupp Panzer-Kanon.



Russian bronze breech-loading 3".5 (4-pounder) rifle.

back and forth over the vent in consequence of the motion of the breech block. This covers the vent until the breech is securely closed. This gun has the usual copper gas-check, which rests against a steel obturator plate. The carriage is on Colonel Engelhardt's system. The brackets are of flanged sheet steel, said to have been hammered out by hand. They are braced by a transom beneath the trunnions, bent so as to be riveted to the lower flange; two through bolts, one of which holds the elevating screw box trunnion socket, as in the Krupp gun; two box transoms; the box bottom; the hand-spike axis and bearer; and the lunette plate. The elevating apparatus is as described for the Krupp field-gun, except that the forward ends of the straps running from the sectoral head are fastened to lugs on the front transom. The elevating screw is double, running in a box, such as used in the Krupp gun. Instead of a hand wheel like the Krupp, a disk with a notched edge is securely fastened to the top of the lower screw; above it and fastened to a collar revolving on the same axis is a hinged lever, on the lower side of which is a tooth which can be engaged with any of the circumferential notches described to turn the disk and work the screw. This lever is about 14 inches long and gives great power in elevation. It can be used with but one hand. The cork buffer is as follows: The axle is held in rectangular loops bolted to a flat piece spanning a curved notch left in the profile of the underside of the checks. This forms an oblong hole, clamping the square axle above and below, but allowing it about 2 inches play from front to ear. With the gun at rest this vacant space is in front of the axle. From each axle arm a stout iron brace runs diagonally back to a point in front of the front box transom. There it is fastened to a square 1¼-inch bar, which traverses the body of the carriage through longitudinally oblong slits in the sides. These slits are about 2 inches longer than the thickness of the bar. Strung upon this bar between the brackets are two eye-bolts about 12 inches long which pass to the rear through the front box transom, and through a loose 1¼-inch plate in rear. There they are held by nuts screwed on to their projecting ends. Now, filling

the space between this heavy plate and the front box transom is about 3 inches of sheet cork in three layers of from 0.5 inch to 1.25 inches thick. These layers of cork were originally of an aggregate thickness of 5 inches, but have been condensed by screwing up the rear nuts. They are also specially prepared by boiling in oil. The function of the cork is now evident. When the gun is fired the gun and carriage recoil together, the wheels and axle tending to remain fixed. The 2 inches of play allowed the axle and through bolt permit this to be done somewhat at the expense of the cork, which is compressed by the operation between the rear plate fastened to the *wheel* and the front plate fastened to the *gun*. By the use of this method the recoil of the gun is said to have been diminished from 3 feet to 1 foot. The gun has been fired about seven hundred times, part of the time butting against an immovable log in rear.

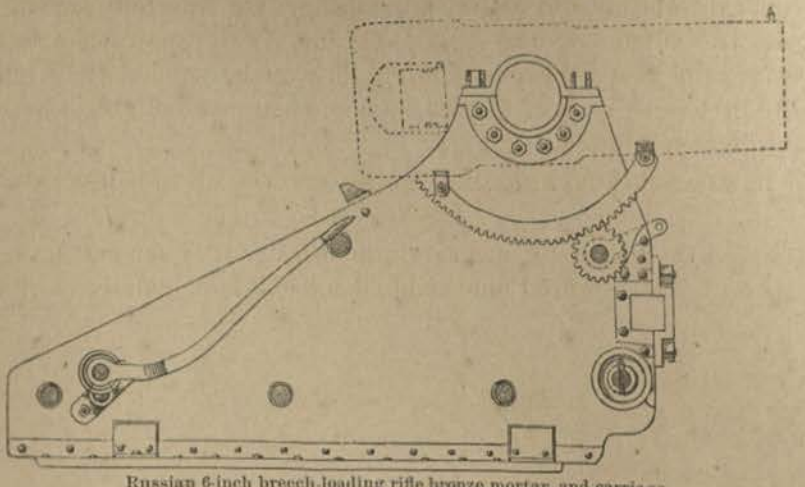


Russian carriage for 4-pounder gun.—Cork buffers.

The trail handspike is of wood, resting in a skeleton iron socket. It swings on an axis bolt passing through the brackets. This bolt also serves to secure the forward end of the trail handles. Just in rear of this axis, and above it is bolted a horizontal strap under which a weighted hook, such as is used for window shutters, engages when the handspike is turned back. The handspike is provided with a cross handle on top. The trunnion beds are secured to the top flanges of the cheeks by flat pieces riveted to the flat part of the cheek, and provided with solid stems forged on them, passing up through the top flange through the trunnion bed and through the cap square. The forward one of these stems is curved forward and makes the joint by which the cap square is removed. The rear stem ends in a bolt, upon which is screwed a nut confining the cap square. The seats, wheels, &c., closely resemble those of the Krupp gun.

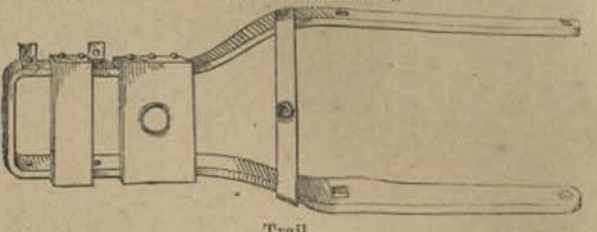
RUSSIAN 6-INCH BREECH-LOADING RIFLE BRONZE MORTAR, AND CARRIAGE.

This mortar is cast by the Lavroff system in a metallic mold, and subjected to pressure while fluid. It is rifled with 24 grooves .6 inch wide

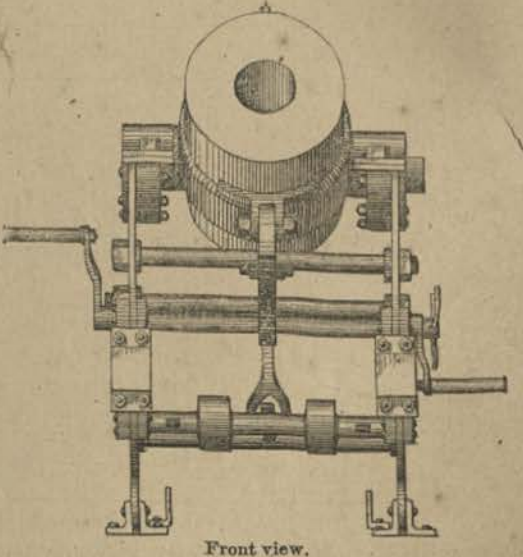


Russian 6-inch breech-loading rifle bronze mortar, and carriage.

.05 deep. The lands are about .125 inch wide; twist uniform. The wedge is solid, of bronze; the left trunnion projects somewhat and is cut so as to give a plain surface passing through the axis of the bore, probably for use with the level. The carriage is on Major-General Lamenoff's system (gold medal, Vienna, 1873). The cheeks of the carriage are of plate-iron, 1 inch thick. They are braced by 7 through-bolt axles, &c. The trunnion beds are bolted directly through the cheeks. The elevation is given by a sectoral-rack moved by a pinion on a transverse shaft, turned by crank outside. The end of this shaft on the left side of the carriage projects through the eye in the crank-arm, and has a thread cut on it. On this thread can be screwed a nut with two projecting arms, by which the pinion can be clamped at any desired point.



Trail.

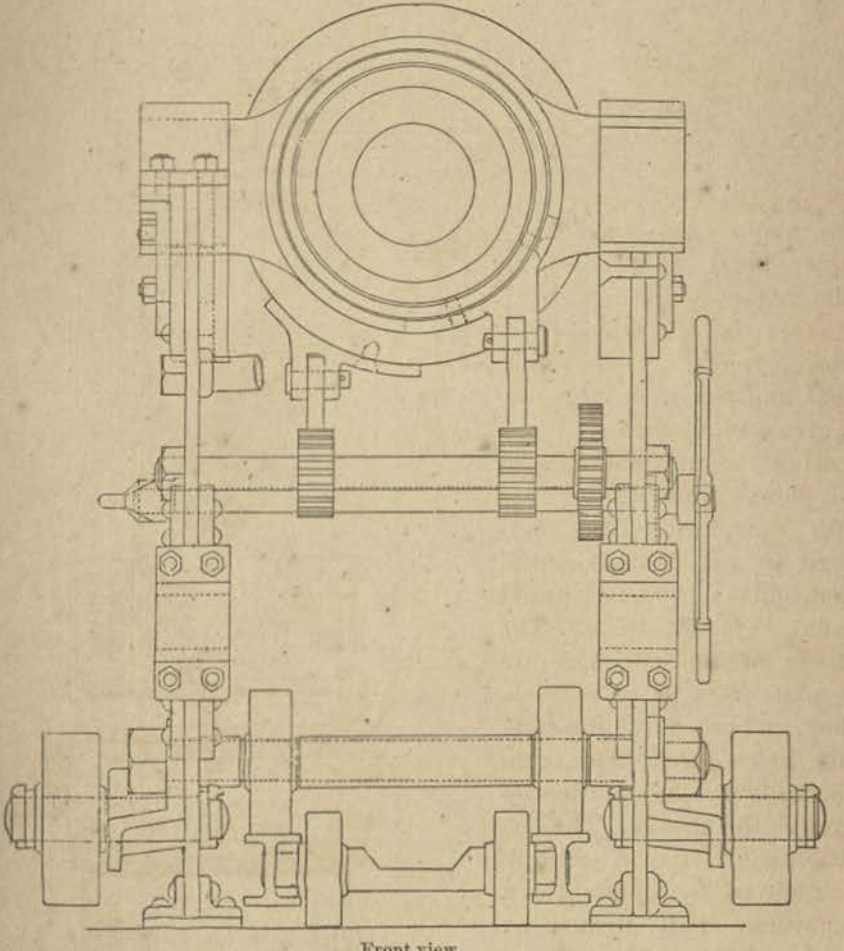


Front view.

The lower front axle supports between the cheeks two truck wheels designed to run upon rails not shown. An eccentric axle in rear with a fixed handle like that of the 24-pounder flank defense howitzer, serves to run the mortar into battery after firing. On the front face of the cheeks are bolted axle boxes. An axle and wheels are provided to this carriage, and also a fork, as shown in the sketch, which may be bolted on the projecting ends of the two lower and rearmost bolts, to serve as a trail in transportation.

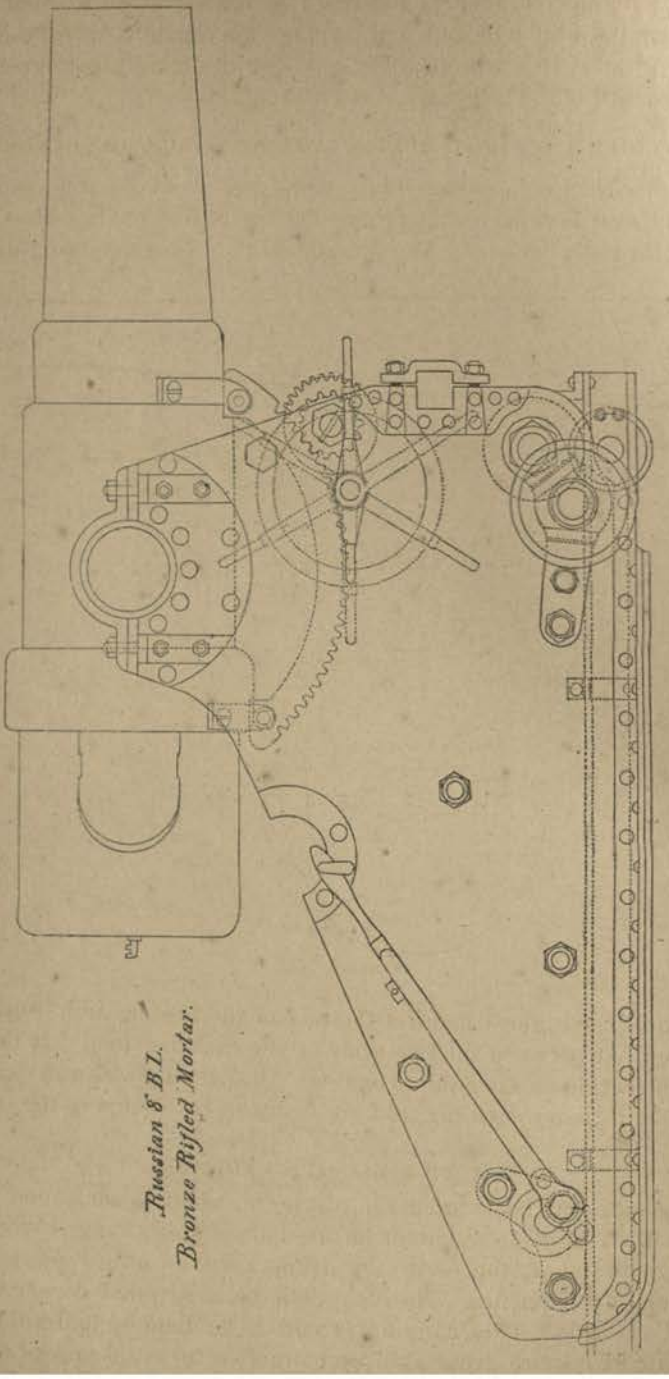
THE RUSSIAN 8-INCH BREECH-LOADING BRONZE RIFLED MORTAR AND CARRIAGE.

This mortar is made of ordinary gun metal. It is not mounted. It is said to have been fired four hundred rounds, three hundred of which



Front view.

were with 17 pounds prismatic powder, with a pressure of 20,250 pounds, and one hundred with ordinary (mortar?) powder, with a pressure of 30,000 pounds per square inch. A drawing is given of a carriage for this mortar similar to that used for the 6-inch mortar, but more complex in its construction.



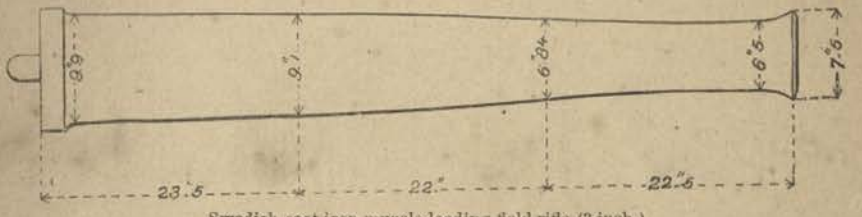
Russian 8" B L.
Bronze Rifled Mortar.

THE SPANISH BRONZE BREECH-LOADING 8-CENTIMETER FIELD RIFLE.

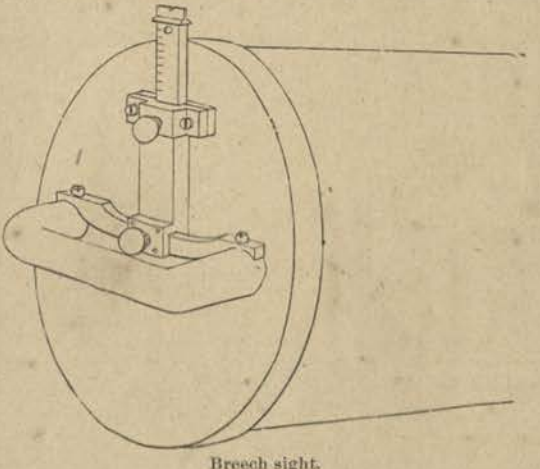
This gun, cast in 1868, is inscribed as having stood without injury one thousand four hundred and twelve experimental fires, besides fifteen in proof. It now appears in good condition, no great erosion being perceptible. The charge is not stated.

SWEDISH CAST-IRON MUZZLE-LOADING 3-INCH FIELD RIFLE.

Rifled with three grooves .8 inch wide, and about .05 deep, square on one side and beveled on the other. On the face of the breech is cast a horizontal cascabel loop. The breech-sight slides in a rectangular box,



Swedish cast-iron muzzle-loading field rifle (3-inch.)



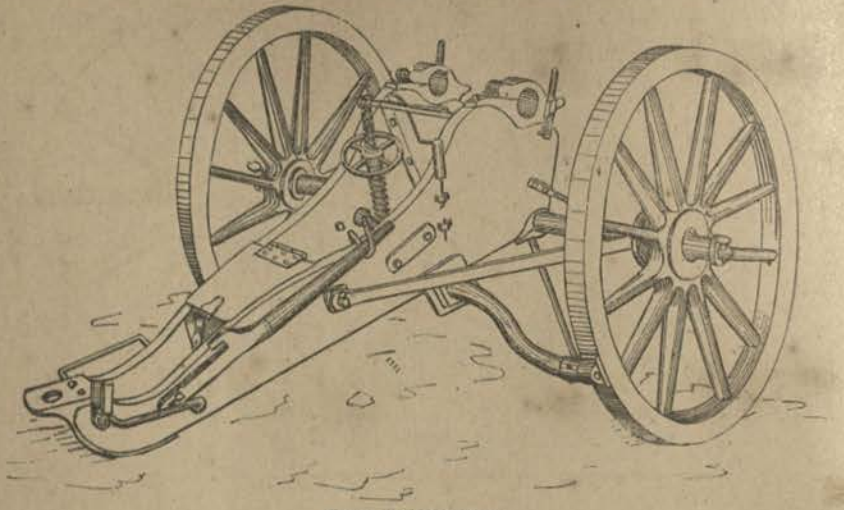
Breech sight.

pivoted at the highest point of the face of the breech, and swinging on a curved bar between the two arms of the cascabel loop. It thus acts in one direction as a pendulum hausse. The priming wire and vent-cover resemble ordinary patterns, and are fastened by thongs to the cascabel loop.

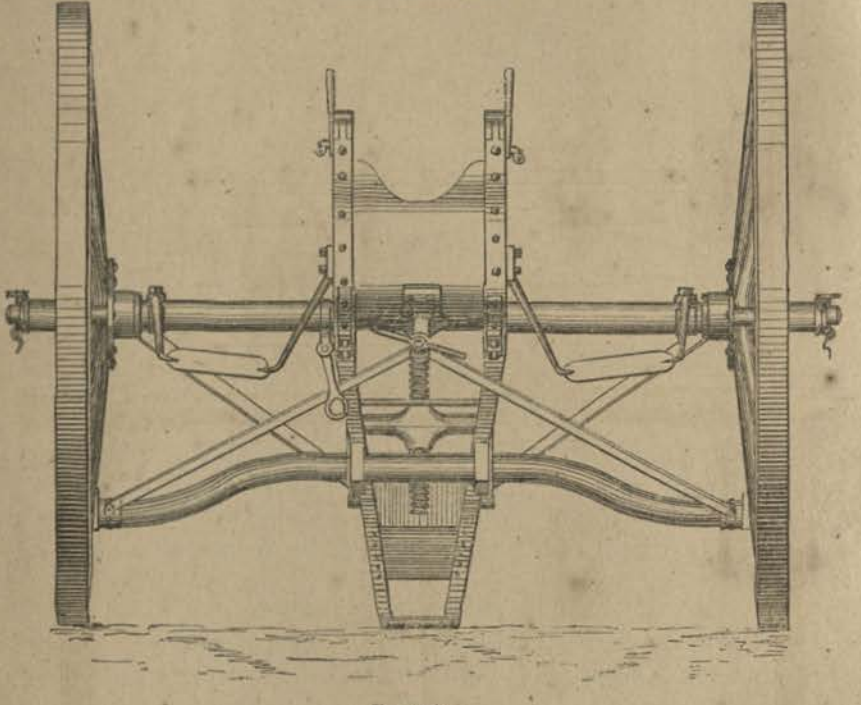
KRUPP FIELD-GUN CARRIAGE.

The cheeks are each formed in one piece, which is continued to form the trail. These pieces are of pressed sheet steel, flanged over along the edge to impart the necessary stiffness and to afford a seat for the necessary attachments. The flanges have a rounded corner and are turned inwards. This flanging is said to be done by hydraulic pressure, and to require great skill and practice to avoid cracks or other failures. The process is secret. The cheek pieces are securely braced

by a series of bolts, transoms, &c., shown in the sectional sketch. This consists of (1) front transom, (2) elevating screw axis bolt, (3) breech transom, (4) elevating screw box bolt, (5) elevating screw box, (6) brace



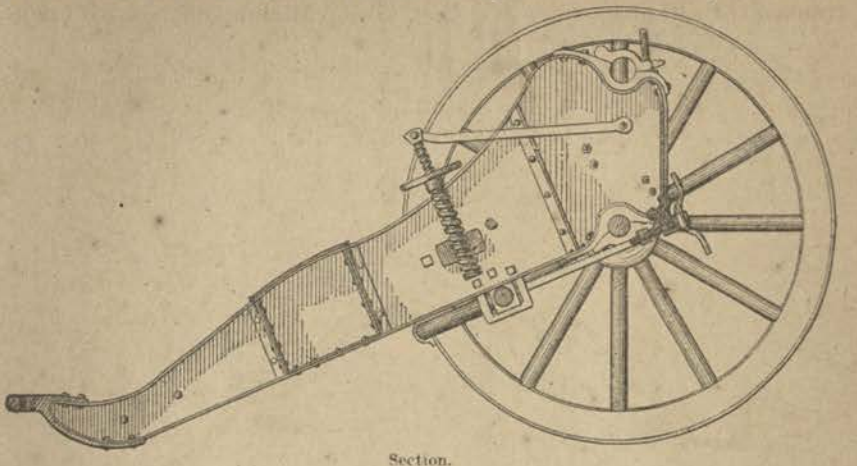
Krupp Field Carriage.



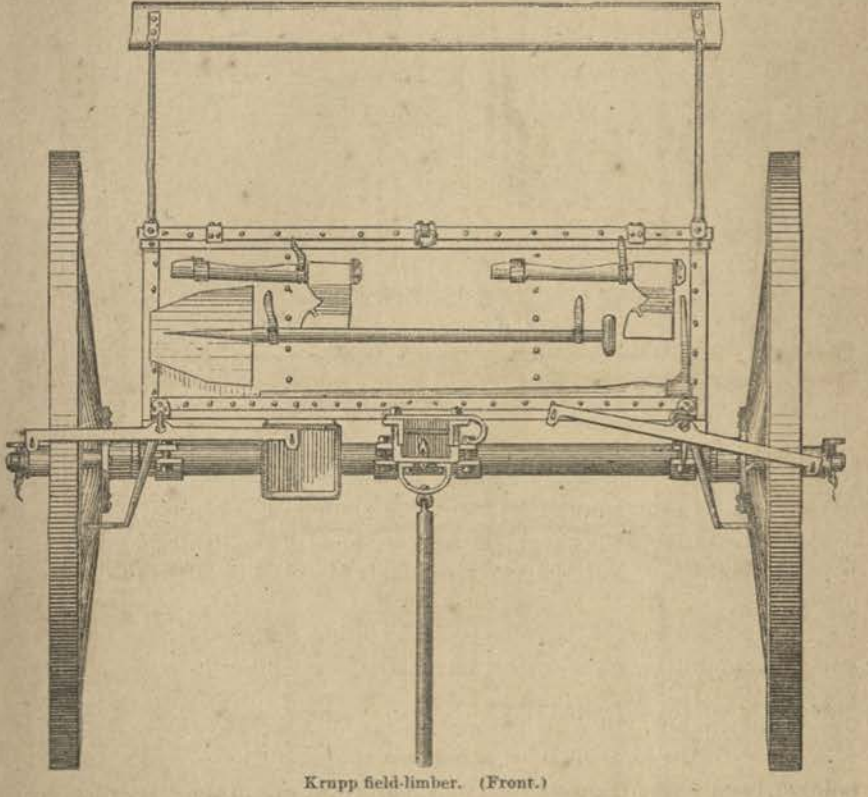
Front view.

bolt, (7) front box-transom, (8) rear box-transom, (9) box bottom, (10) trail plate, (10) axle, (12) gun. A considerable rise is given to the profile of the cheeks in rear of the trunnion beds. The trunnion beds are bolted on the flange. The cap squares are hinged in rear and fastened

in front by a swivel pin. The axle is of round steel. It is braced back to the trail on each side. The elevating screw is double, the hand



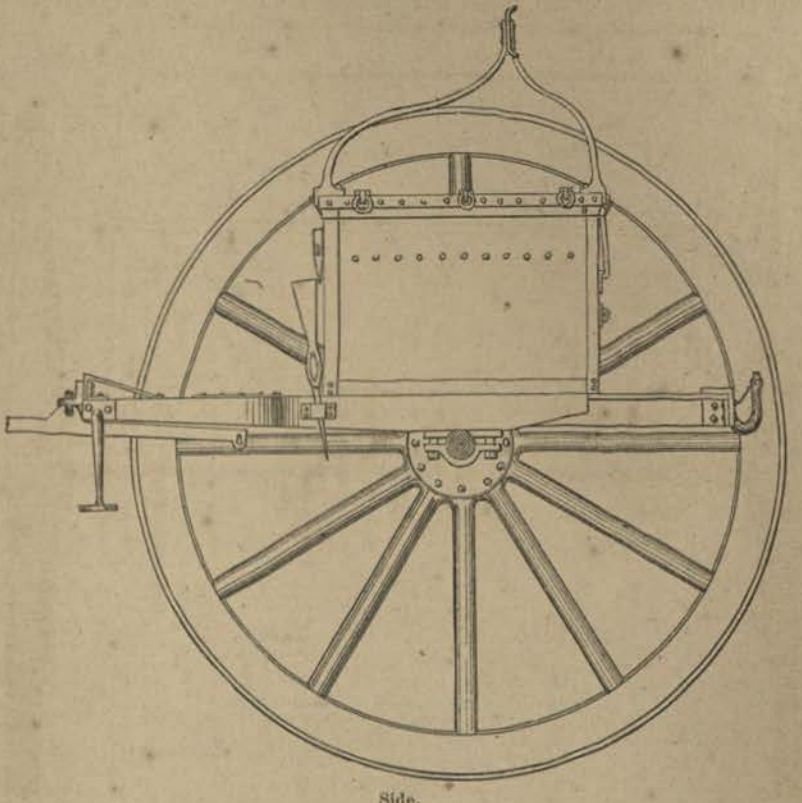
Section.



Krupp field-limber. (Front.)

wheel being connected with a left-hand screw working in the stem of a T-shaped box. This screw is hollow, and contains a right-hand screw,

which supports the gun. The effect of this is that, as the lower screw turns into the box, it draws in the upper screw correspondingly.* The upper screw swivels in a sectoral shaped piece rocking on the under surface of the breech. This piece is connected by two iron straps with a bolt joining the cheeks just below the trunnions. As the horizontal arms of the T-shaped screw box terminate in trunnions which swing in bearings inserted through the cheeks from the outside, the whole system is



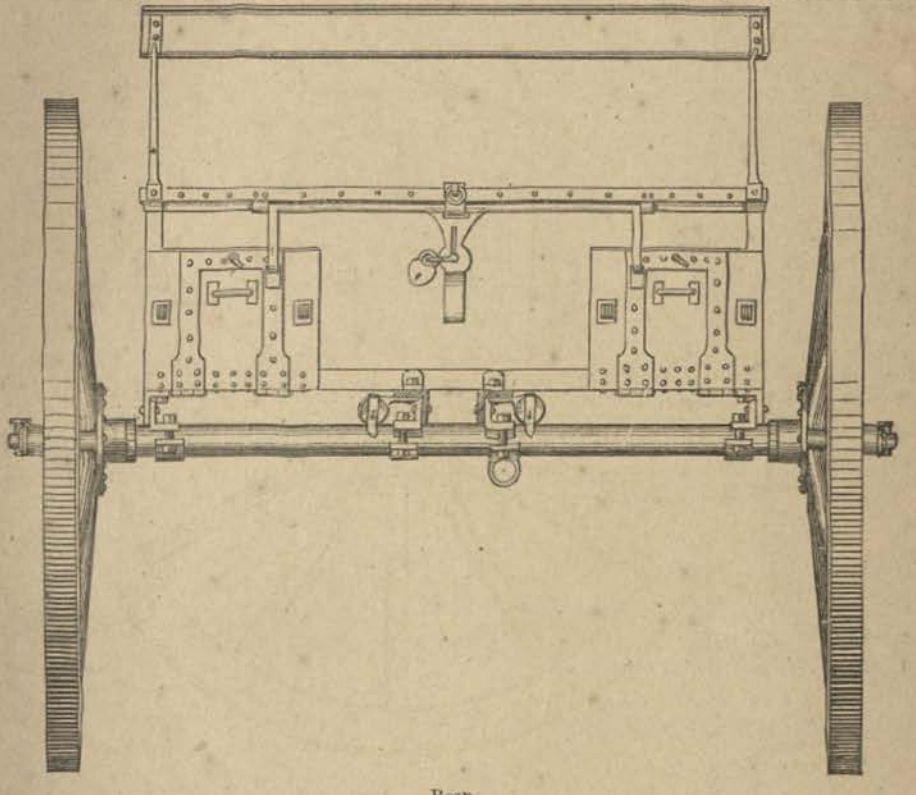
Side.

able to follow the movements of the breech of the gun as it is raised or depressed. These trunnion bearings are made in one piece with a short heavy strap outside the cheek, the forward ends of the straps being joined by a through bolt and the rearmost ends simply bolted to the nearest cheek.

The trail box serves to hold tools, cleaning materials, or a round or two of ammunition; the operation of the handspikes is evident in the sketch. As this handspike is fixed, a separate lifting bar is carried under the limber. The priming wire has a stout wooden handle, and is secured to the trail by a long leather thong. The sponge staff is so seldom used that it is fastened to the trail, inside, by a thong, its forward end being carried in a loop under the axle. The charge is

* In the perspective drawing the upper screw is left hand by mistake.

passed home with a short rammer carried in the limber chest. The brake consists of a steel or iron tube, moving in guides beneath the trail. It is connected by means of braces at each end with a screw on the front transom, by which it can be drawn tight against the wheels. This screw is so placed as to be conveniently served while the piece is in motion by the cannoneers, who are mounted on seats (not shown) on each side of the gun. The forward part of these seats rests on the axle. In rear they are supported on the axle brace. A foot-rest hangs in front.



Rear.

The seats are backed with wire netting covered with sole leather, and have cushions.

The following dimensions, &c., are taken from Herr Krupp's catalogue: For the 8.7-centimeter gun-carriage, the weight of the carriage, without implements, is 1,122 pounds. The pressure of the trail, with gun mounted and all implements in place, 341 pounds. The elevating screw admits of 24° elevation and 8° depression. The height of the carriage is 3.64 feet. Price at Essen, with implements, $586 gold. For the 7.5-centimeter gun-carriage the weight of the carriage, without implements, is 1,014 pounds. The pressure of the trail, with gun mounted and all implements in place, 224 pounds. The elevating screw admits of 25° elevation and 8° depression. The height of the carriage is 42.6 inches. Price at Essen, with implements, $570 gold.

THE KRUPP FIELD-LIMBER.

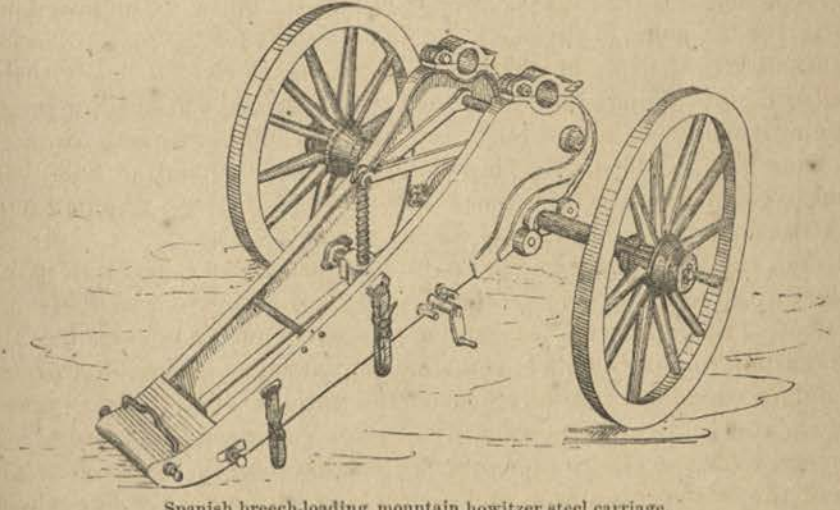
The chest is bolted down upon four pieces of angle iron, two together in the middle and one at each end of the axle. These pieces of angle iron rest upon the edge and are clamped to the axle by means of short pieces of angle iron hollowed out to fit the axle and riveted to the vertical face of the main bearer and held by bolts and nuts to straps, which embrace the axle from beneath. The middle pieces of angle iron extend to the rear, where they are united to form a bearing for the pintle hook. They extend forward and form the fork. The side pieces (hounds) run forward beyond the limber box, and are curved outward to give a bearing to the foot-boards. To them are fastened the swing trees of flat steel, punched at each end for the trace hooks. The limber chest is divided into five general compartments. One large compartment, occupying about the middle third, is reserved for the powder. This is carried in seven leather boxes holding five cartridges each. These boxes have swinging lids, and are partitioned off into cells. This portion of the box is accessible through the lid which swings up in the ordinary way. The lower portion of the extreme thirds in length of the box is taken up by the projectiles. Their place is indicated by the small doors shown in the sketch. These doors open downward to a horizontal position, and are sustained by arc-shaped braces. When open they disclose the ends of three sheet-iron boxes, which, being drawn out, will be found to contain five percussion shell each. These boxes are partitioned off for the shells. The lid also contains five wooden bumpers, hollowed out to fit over the point of the shell, a hole being left for the fuze. The lid of these boxes is kept shut by means of two hasps riveted firmly to the front edge of the lid. In closing the box a barb on each of these hasps springs over and engages with the top edge of a hole cut directly through the front side of the box. These holes are large enough to admit the hand in order to release the hasps in opening. The box has bail handles at each end accessible in a similar way.

Under the limber, in two horizontal cylindrical sheet-iron boxes, furnished with lids and long leather straps, two charges of canister are carried. The circle below is for a spare sponge-staff. Above each of the ammunition compartments is a smaller compartment, accessible through the lid, in which are carefully packed the various small articles necessary in the service of the gun, viz, spare gas-checks, lanyards, fuze primers, tools, level, friction primers, leather breech cover, &c. The top of the box forms a seat, and is provided with a back. The wheels have twelve wooden spokes, six wooden fellies, and bronze hubs. The tire is of iron.

The manner of simultaneously closing the lid and the two small shot compartments with one lock deserves attention. In front of the limber-chest are strapped two heavy hatchets, one pick and mattock combined, and one shovel. An iron bucket with lid, about ten inches square, is

carried in an iron loop under the foot-boards. The mouth of the bucket is to the rear, the bail being fastened to a hook on the lower front edge of the limber chest. A small box for cleaning materials lies in between the angle irons which form the fork, the lid forming par of the foot-boards. The pole is of wood, bolted through the forward end of the fork. It is further secured by a stirrup passing under the fork. The nuts which hold down this stirrup also secure a top strap, which is extended and bent downward to form a loop designed to hold the forward end of a wooden lifting bar. The rear end of this lifting-bar passes under the chest and over the axle to a point near the left-hand canister-box. The linch-pins are made with a large flat head, roughened to serve as steps. They are only used as such for the limber, but are interchangeable with those of the gun. The linch-pin is secured by a horizontal guard-pin passing through its lower end. The guard-pin is fastened by a leather thong passing through an eye at one end of itself. The head of the pole is formed into a hook at the end of a tubular sleeve, and connected with a flat steel swing-tree by two rings. These rings are retained in the hook by a small guard-ring through the point of the hook. Two pole chains are fastened to a large ring lying loosely on the tubular sleeve, and kept there by a staple. The ends of the swing-bar are punched with holes for the trace hooks. Cost of limbers, with implements, at Essen, $637, gold.

THE SPANISH BREECH-LOADING MOUNTAIN HOWITZER STEEL CARRIAGE.



Spanish breech-loading mountain howitzer steel carriage.

The flasks are of iron stamped according to the Krupp method. They are united to the round steel axle by a double under strap, hinged to the cheek in rear of the axle and secured by a transverse pin in front. An extra thickness of sheet steel is fitted between the flanges beneath each trunnion bed inside the cheek, and secured in front of the axle by shoulders on the elevating screw guides axis bolt, and a separate brace

bolt joining the re-enforce pieces in rear. The elevating screw-box works on trunnions through the right hand, one of which passes a crank shaft turned by a handle outside. Inside is a beveled gear. In rear of this the flasks are braced by two more cross-bolts, the trail plate and handle. The trail plate is quite long and bent to form a tool-box closed by a lid in front between the flasks. On each side of the trail project the shaft pins. The trunnion beds are formed on a continuous iron strap, running from beneath the flasks in rear of the axle to a point in rear of the trunnion beds; on this piece are formed the hinges for the axle straps. The cap squares are jointed to this piece, and are secured by transverse pins in front. The implements are carried in leather loops on the side; one of them carries a wire brush. The wheels are of wood with wooden naves. The shafts are provided with two cross-bars framed to them near one end, the farther one is notched to receive the trail, the forward one has two stout hooks on its upper surface which pass around the rearmost pins in the trail. The traction is direct by loops on the shafts, two are provided, the forward one answering for the lead horse. A set of lifting bars is provided with each piece for carrying it by hand. Some of these carry notched bolsters for the gun and others collars for the carriage, &c.

CARRIAGE FOR KRUPP 24-CENTIMETER SEA-COAST BREECH-LOADING RIFLE.

The carriage, chassis, &c., are on essentially the same plan as the 35.5 centimeter carriage already described. The main differences are as follows: There are only 2 transoms between the cheek-plates besides a horizontal web joining the two sides beneath. The rear truck wheels are on eccentric axles moved by handspikes in outside sockets. There is but one hydraulic cylinder, the piston for which is attached as in the 35.5 centimeter gun. The spring buffers are reduced to two, front and rear. There are but two pairs of traverse wheels, the forward ones rolling on a rail cast with the pintle socket. The foot-boards are of wood. The crane is without gearing, a simple purchase serving to lift the shot, and a cross handle on the body of the crane sufficing to turn it. The elevating apparatus on the right side is as in the 35.5 centimeter gun. On the other a simple inside pinion, with an exterior socket wheel, serves to help the train of wheels when necessary. No dial plate is provided for indicating the elevation. The chassis rails are rolled solid I beams, 11 inches by 6 inches with an inch and a quarter web. Beneath the front bumpers two short pieces of I beams are inserted to give solidity against shocks in coming into battery.

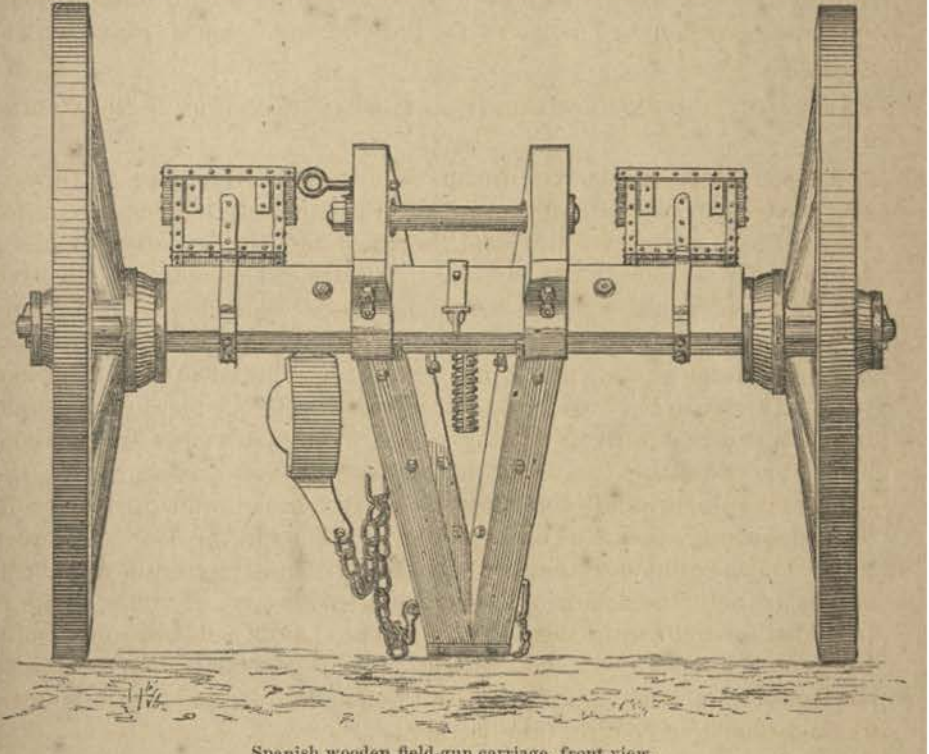
RUSSIAN IRON FIELD CARRIAGE.

A Russian iron field carriage is shown of essentially the same construction as the mountain howitzer carriage. The brackets are cut from plate iron and stiffened with angle iron, with the edge turned in, riveted along their edges. There are no transoms, but lateral stiffness is se-

cured by six through bolts and a trail plate. The cap squares are as in the new model carriage described. The elevating apparatus is on the Krupp model. The axle is square and stiffened in front by an L-shaped angle iron, the horizontal web of which is flush with the lower surface of the axle. This is strapped on to the axle body. The handspike of wood revolves on the lowest through bolt, and is secured when back by passing between two vertical curved bars, through the open end of which a pin passes to confine the handspike when set. The wheels have twelve wooden spokes and wooden naves. The linchpin is secured by a leather strap passing through a loop in the head of the pin and an eye through the pin below the axle. It is secured by a buckle. The same linchpin is used on the new carriage.

SPANISH WOODEN FIELD-GUN CARRIAGE.

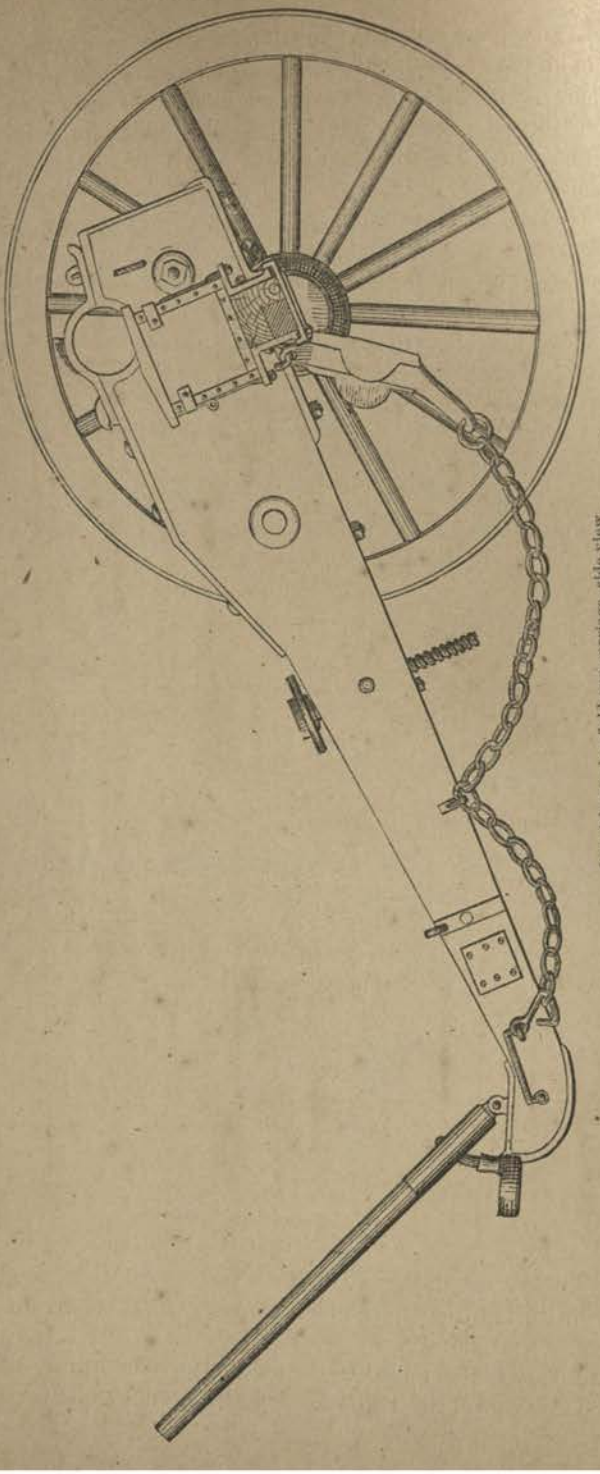
The stock is made in two flasks, notched to receive the axle body and united in rear by the trail plate, &c. They are also united by two through bolts, one in front and one in rear of the axle, and the box of the elevat-



Spanish wooden field-gun carriage, front view.

ing screw. They are fastened to the axle body by long under strap plates turned up in front to receive the lower end of the trunnion bed-plates.

The axle body is also joined to the axle by an over strap notched into the axle body above, the two ends being united by a strap beneath.



Spanish wooden field-gun carriage, side view.

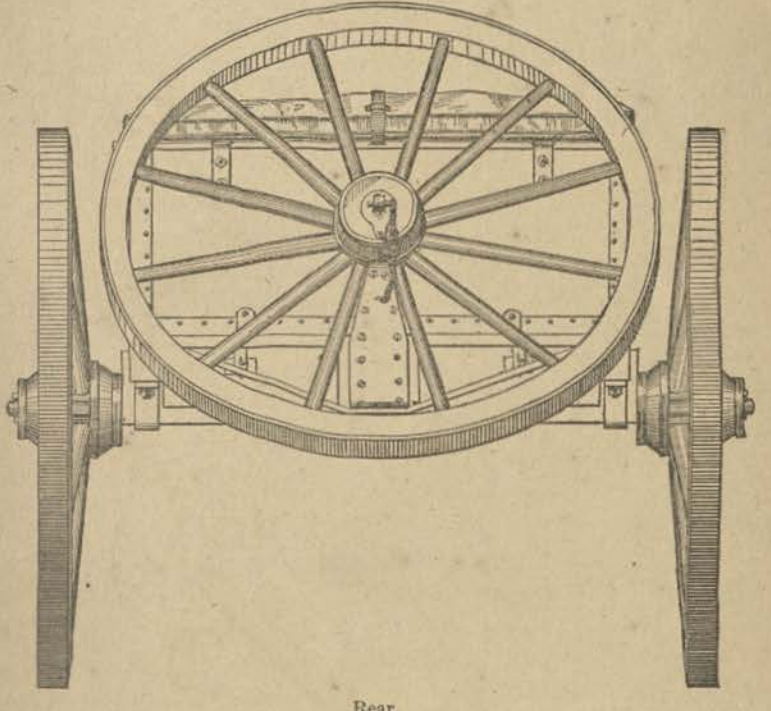
The upper side of the over strap projects, forming foot-rests for the ammunition boxes on each side of the stock. These boxes hold four rounds each. The handspike is hinged to a fixed joint on the trail plate. When in use it is turned back, engaging with a curved stud which passes through the iron socket at its lower end. It can be secured by a transverse pin passing through the end of the stud.

The implements are variously carried. The long sponge on the right, by an eye at its end engaging with a hook just in front of the wheel plate. The shaft passes through a fixed ring in front. The short rammer and chamber sponge on the left by hanging from a square vertical hook on the cheek, which passes through a hole in the shaft near the sponge head. The rammer head slides into a fixed ring in rear. A complicated shell extractor is also slung on the left.

The other details are essentially as in the United States service.

THE SPANISH CAISSON.

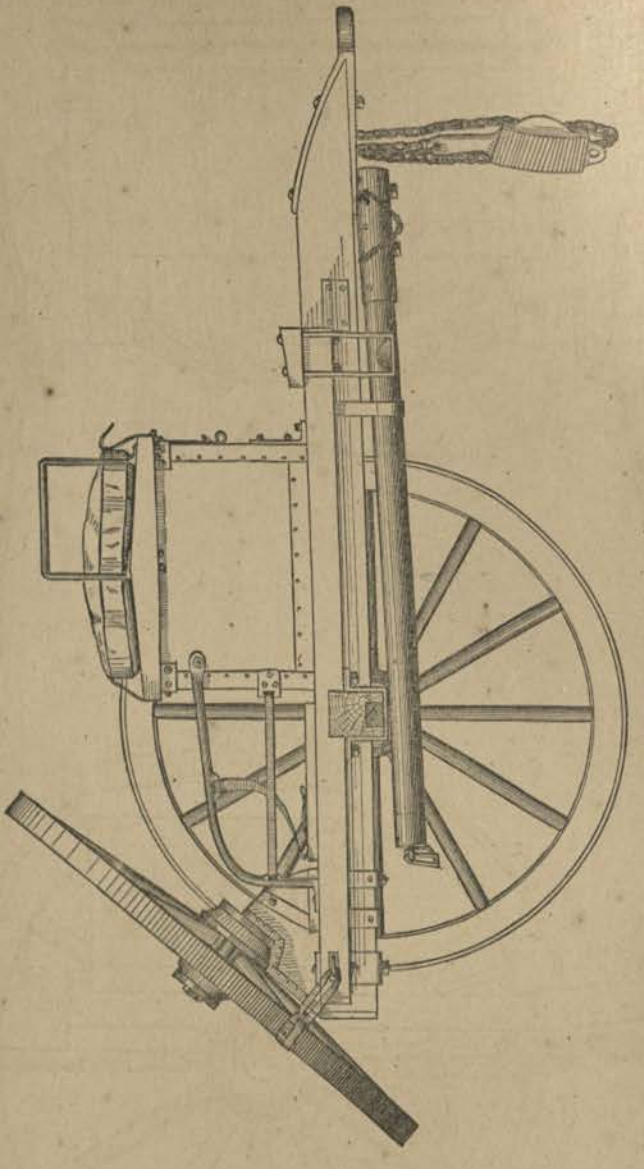
The body is formed of the stock and two rails notched into the wooden axle body, to which they are fastened by under straps. They



Rear.

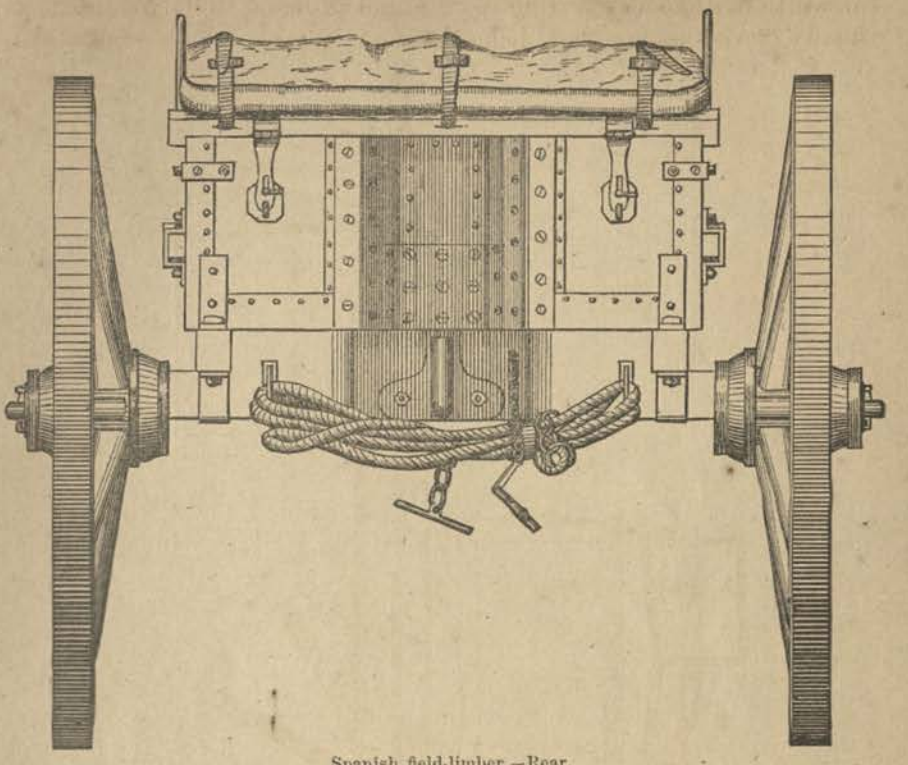
are united by the front and rear foot-boards and by the wheel bed brace. The chest is made larger than for the limber and is set well to the front to balance the spare wheel. It is secured by the same means as the limber chest, and by two curved rods forming a sort of inclosure for baggage, forage &c. The spare wheel rests upon an oblique notched bed,

the width of the stock resting upon it and fastened to its rearmost extremity. An axle arm and linch-pin keep it in place. Two small boxes,

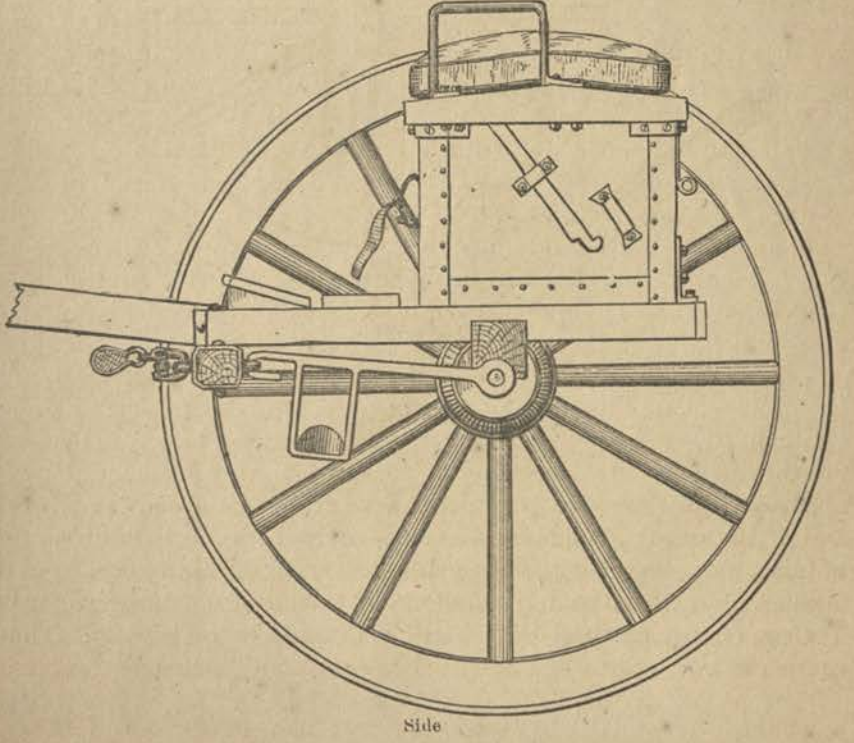


Spanish caission.

apparently for fuzes, &c., are placed between the rear ends of the rails and of the stock. The caisson chest is divided interiorly into two tiers of trays, the lowermost, for projectiles, covering the entire bottom of the chest, is partitioned as in the limber. The shells rest on rope grommets. The upper tray, in three main parts, is devoted to the powder. This is carried in two large flat zinc boxes on each side, each one containing

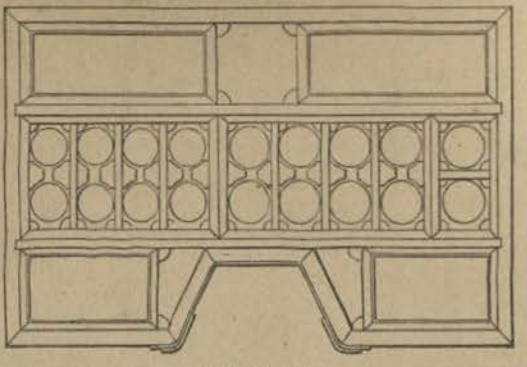


Spanish field-limber.—Rear.



Side

twenty cells. The lids are halved to avoid exposure in opening. The other compartments are for tools. The limber is arranged as in the case previously described, except as to the interior partitions of the chest.



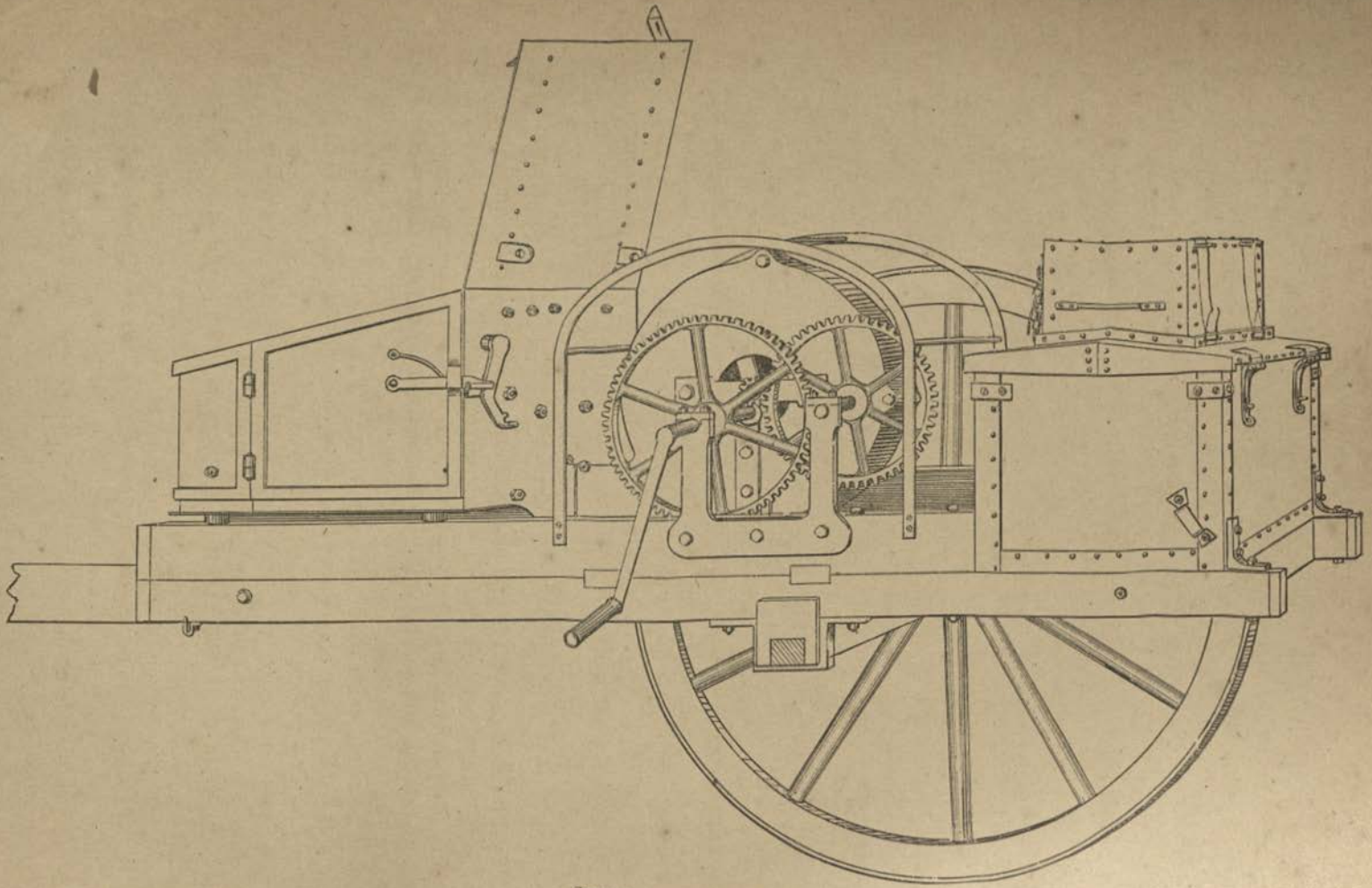
Top of chest.

These are like those of the caisson chest, the shot all beneath, the powder all above. The caisson carries beneath it a spare pole in two sections connected by a sleeve joint and transverse pins. The limber carries in iron loops on its side a pickax and a felling ax.

THE SPANISH FIELD-LIMBER.

The body is made upon essentially the same model as that of the United States. The chest, however, is very different. Being set back to balance the weight of the pole, a vertical trapezoidal groove is left on its rear face, just over the pintle-hook. The attachment of the chest is worthy of notice. It is secured at three points. One in front, on the fork by a square staple there, into which the foot of an L-shaped foot-brace fits. The rear foot-braces are secured by T-headed bolts to the hounds, the heads of these bolts entering in one direction through the feet of the braces. An iron rod joins the axle-arm to the splinter-bar, and serves to sustain a foot-step. The middle of the limber chest running along its length is occupied by the projectile trays. There are four of these in two tiers, each tray carrying eight shots. The projectiles are kept separate by sliding cleats across the tray, with two quadrangular steadying cleats at their middle.

The bottom of the trays is counterbored from above for the base of the projectile, and from below for the point of the corresponding projectile in the tray below. The cartridges are placed loosely in four deep zinc-lined boxes in corners of the chest. The vacant spaces between are used for tools, spare parts, &c. The front foot-board is divided in its length, and forms lids for a pair of boxes between the fork and the hounds, for ammunition, implements, &c. The brace for the chest lid is placed outside to save room. It is of iron, and notched so as to fall against the edge of the loop through which it travels when the lid is up.



Face page 821.

Spanish traveling forge.

SPANISH BATTERY WAGON.

The lower part of this body is divided into three main longitudinal divisions, the middle one being the widest. These are covered by sliding boards in three transverse sections. They are accessible from the rear through the tail board, or from the front by two similarly folding doors, for the outside compartments. The bearers are arranged on the same principle as in the caisson, 6 vertical iron bolts on each side joining the top and bottom rails. These bolts pass through staples in the side boards. The top, made of long wooden rods quilted in between two thicknesses of canvas, rests upon three steel bows. It is secured by eleven straps to the top side board. At each end of the top rail are rings, between which containing ropes can be stretched. The limber is as in the caisson.

SPANISH FORGE.

The body resembles that of the caisson, except that the rails are much deeper in front to give room for the hearth. A tool-box is set in rear, and a plate-iron box in front, forming the fire-place. The sides of this turn out on hinges as well as the top. Wind is obtained from a rotary fan over the axle. This is driven by a detachable crank passing between two of the spokes of the rear wheel and animating a train of four spiral-geared wheels. The shaft bearings are necessarily very long, and the entire apparatus very frail and bulky. Inverted on the tool box is strapped a heavy plate-iron box without a lid, the object of which is not apparent. The forge carries a spare pole, as in the caisson. Its limber is similarly divided to obtain a low center of gravity.

SPANISH SEA-COAST CARRIAGE.

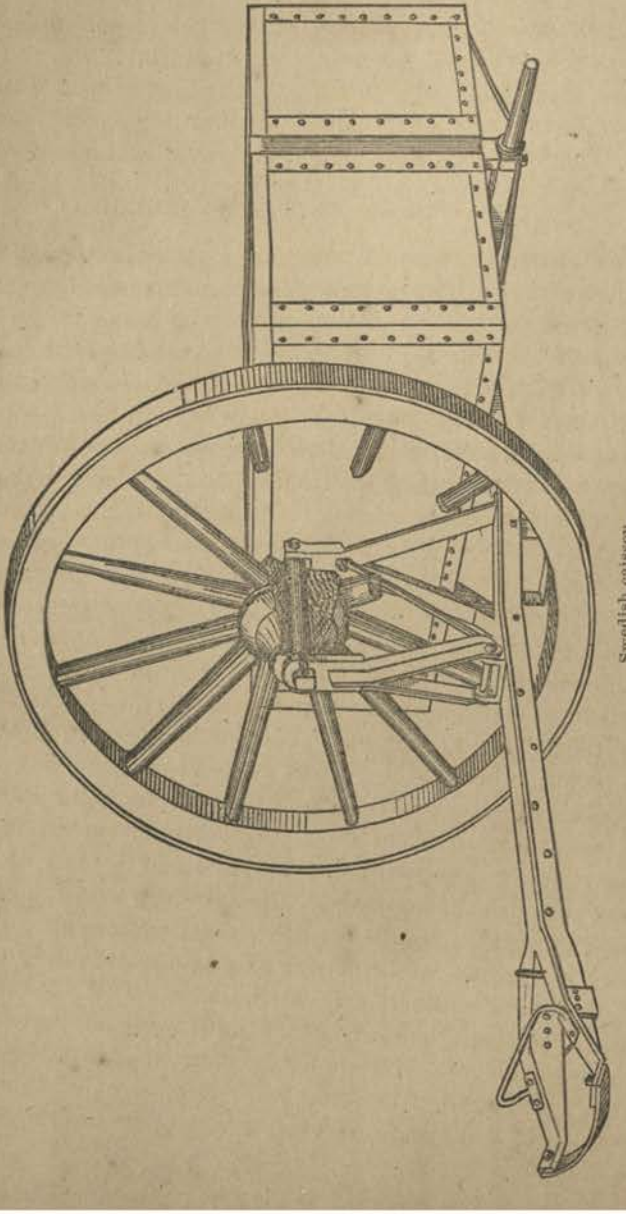
The top carriage is made of a single thickness of plate-iron, stiffened by being bolted between radial horizontal braces. Four of these are radial. The cheeks are united by a diagonal single transom, as in the Parrott system, and two horizontal transoms front and rear. The rear one carries the elevating screw. The carriage is thrown in rolling friction by two eccentric axles front and rear. The wheels have radial handspike sockets, and have serrated edges to avoid slipping. Recoil is checked by separate friction clamps, like Parrott's.

The chassis rails are built up as in the 15-inch carriage. The rails are quite long and are joined by seven transoms. One above in front, one beneath in front, and one beneath in rear. The pintle strap is hinged to the forward horizontal transom below the rail. The forks are low, the inclination of the chassis being provided for by an offset in the platform. There are two traverse circles, trough-shaped, and of about twice the width of the wheels. The face of the wheels is considerably convex, to fit the troughs. They are without handspike sockets or gearing, &c.

The gun can be pulled back from battery by a purchase reeved between eyes in the top carriage and the chassis rail. The gun is altered on the French system. It comprises a cast-iron body hooped with steel. Its shape is peculiar—cylindrical to the trunnions; then by two offsets reduced to a smaller cylinder, then by two conical surfaces brought to the swell of the muzzle. It fires a stud projectile with two rows of studs, the forward ones circular and of copper, the rear ones oblong, of brass.

THE SWEDISH CAISSON.

This resembles essentially the construction of the limber before described. The angle iron bearers are prolonged to the front, where they



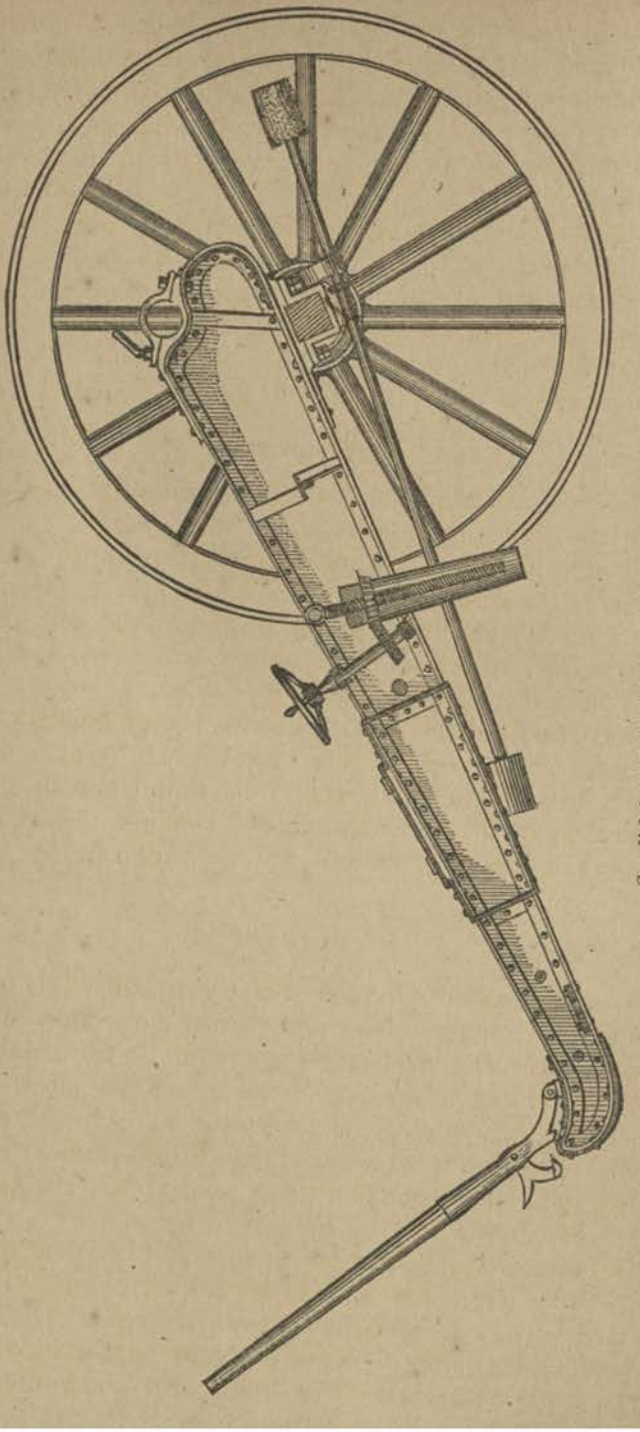
Swedish caisson.

diverge and are joined by a conical friction circle to fit that of the limber. They are still further braced by a straight iron strap containing the lunette beneath them and a round iron handle crossing them above. The spare wheel is carried in front of the ammunition chests on the body of the caisson, being supported on a horizontal pin between two ∧-shaped vertical braces, standing on the rails in front of and behind their junction, where they separate in rear. The front ∧ brace is hinged on the body so as to fold down flat when the wheel is in use. The carrying pin is hinged to the rear brace for a similar purpose. The wheel is put on by turning the wheel down so that the center will come in the plane of the front fork of the body. The wheel is carried in this position to avoid the evil consequences attending its former position in rear of the caisson. When so placed the emptying of the front chest of the caisson body would relieve the sweep-bar from the pressure necessary to balance the weight of the pole. The iron stirrup in front is for the spare pole, &c. The bearers are prolonged in rear to sustain a foot board.

THE SWEDISH IRON GUN-CARRIAGE.

The stock is made of profile sheet-iron plates, stiffened with angle iron, riveted with the flange (brackets) turned inwards. The stock is braced between the sides by (1) curved front transom, (2) X-brace of angle iron half-way back from trunnions riveted to bottom flange and side plate, (3) trunnions of elevating screw box, (4) strap forming step for foot of shaft in hand wheel, (5) strap for top bearing of same, (6) brace bolt against which the diagonal braces to the ends of the axle arms rest, (7) front box-transom, (8) bottom of box, (9) back of box, (10) top of same, to which the lid is hinged, (11) plate containing pintle eye, (12) shoe curved up over end of trail and riveted above and below, (13) strap on which hand spike hinges, (14) gun, (15) axle. The angle iron is strengthened in front by a heavy strap of iron, which passes around the cheek from a point in rear of the axle below to a point half way up the front of the cheek; there it terminates in a hook standing out to the front. It is continued by a heavier piece forming the trunnion bed, which is also riveted to the angle iron. A brace inside the cheek reaching from this trunnion bed to the bottom angle iron is riveted to the sides of the cheek. The cap squares are fastened on by bolts with ⊤-shaped heads to keep them from turning. The heads of the front bolts pass through mortises in the upper flange and are held in place by transverse gravity key pins from the outside. The rearmost nuts are made with a long stem, serving as a handle for the nearest cannoneer.

The stock is fastened to the square axle by straps bolted to the lower flange of the stock on each side of the axle. The nuts on the bolt below confine, between themselves and the D strap above, curved hooks to hold the implements. The eye for the worm staff is independently secured to the axle between the other two. On each side of the gun stock is a pair of loops and straps, serving as a support for the seats. The



Swedish iron gun-carriage.—Section.

front part of the straps is prolonged to form a foot rest. A third point of support for the seats is found in rear upon the diagonal brace. The seat is made in box form, resting on three cylindrical rubber springs. The lid is hinged in front and secured by a spring catch in rear. In opening, it turns bodily, carrying cushion back, &c., with it. The cushions are made of stuffed canvas drawn down to a central hole through which the water escapes. They are fastened with thongs to the framework of the back. The wire netting of which it is formed is covered by a plate of sole leather buckled on to the frame.

The wheels are of wood with wooden naves, 12 spokes each. The linchpin is merely held in place by a leather thong passing through an eye in its lower end. The elevating apparatus consists of a screw hinged to a loop cast on the bottom of the breech of the gun.

The nut is made to revolve by bevel gearing moved by the oblique hand wheel above it in rear. The nut revolves within a box swinging in trunnions, as in the Krupp carriage. The lower portion of the elevating screw is protected from dust, &c., by a leather bucket riveted to the collar of the gear wheel above.

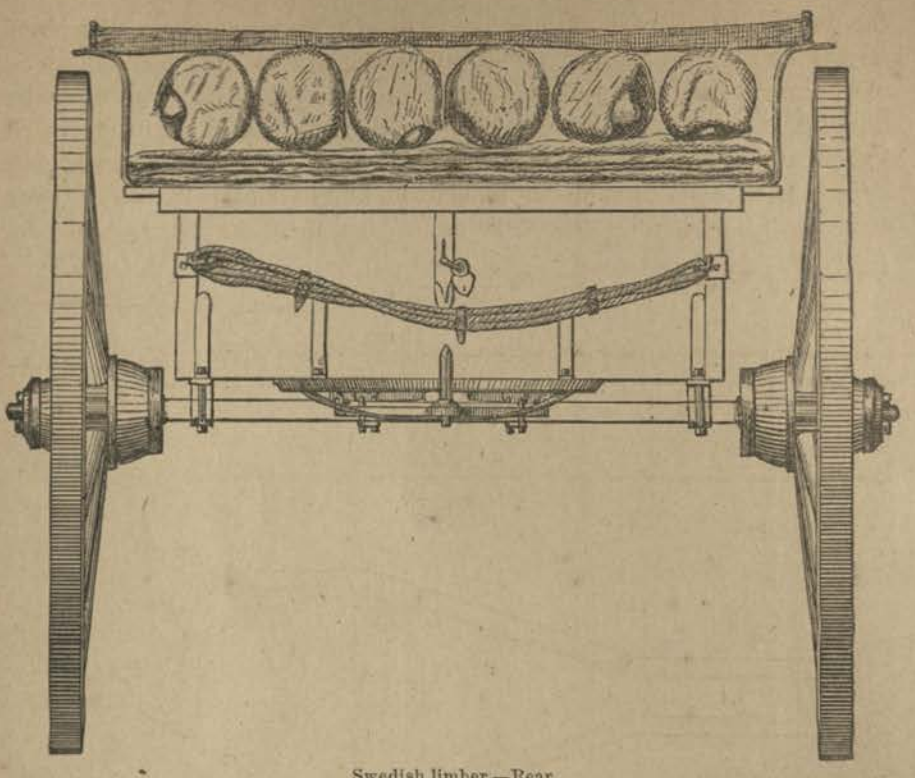
The handspike is fastened by a hinged joint to a strap crossing the upper portion of the trail. It is provided with a gravity catch engaging with a notch in the rear surface of the trail. At the same time a stud on its under surface enters a hole in the top of the shoe and steadies it laterally. The shaft of the handspike is of wood.

The rammer-heads of the two staves rest in iron buckets riveted to the under flange of the socket. The staves rest in front in the hooked loops already referred to, being kept from falling out to the front by collars formed upon the staves in rear of the loops. The worm passes through the middle loop on the axle, and is secured in rear by a strap.

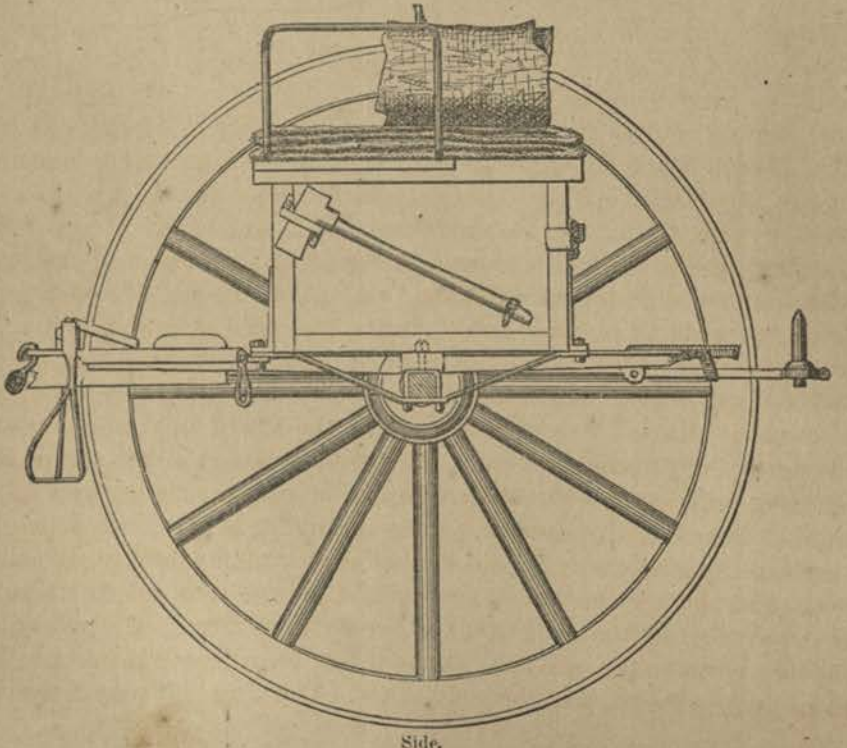
SWEDISH LIMBER.

The body of the limber is formed of two straps of angle iron resting on edge on the axle-flanges above and turned out. They are about 10 inches apart in rear, but are bent so as to meet in front and form the fork. They are united to the axle by means of flat pieces riveted to them and formed with solid stems projecting on each side of the axle, and furnished at the lower extremities with threads; upon these threads nuts are screwed, which confine a strap passing beneath the axle and perforated to receive the body of the screw stem.

The body projects about 12 inches in rear, and is bolted to a semicircular sweep-bar of angle-iron, bent with the edge up, and thus forming on its forward surface a conical bearing for the trail. The extremities of the sweep-bar are united by a strap of iron bent downwards in the center. The pintle is formed with two horizontal arms running out from its base as from the apex of a V. These bars are jointed to the ends of

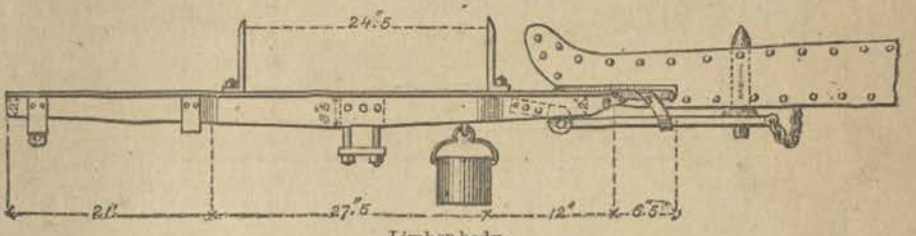


Swedish limber.—Rear.

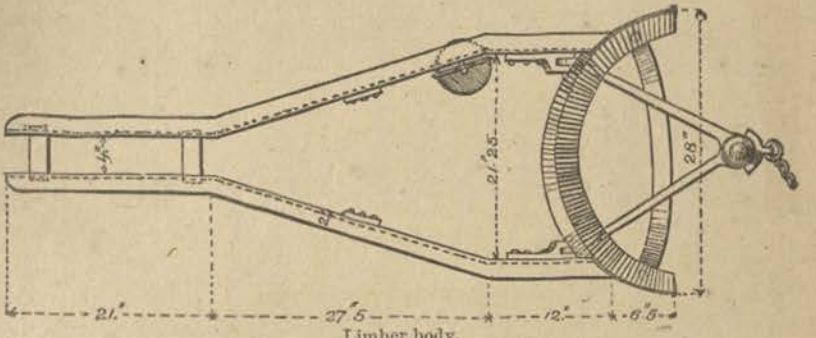


Side.

the body, just in rear of their junction with the sweep-bar. The connection is formed by slit pieces riveted firmly to the vertical sides of the angle-iron. These arms pass under the sweep-bar and over the hanging strap, joining its extremities. They unite in the pintle, which stands about 5 inches in front of the strap, 15 inches in front of the sweep-circle, and 22 inches in front of the limber chest. It is quite long and heavy, and has no key. The joint above mentioned is probably for



Limber body.



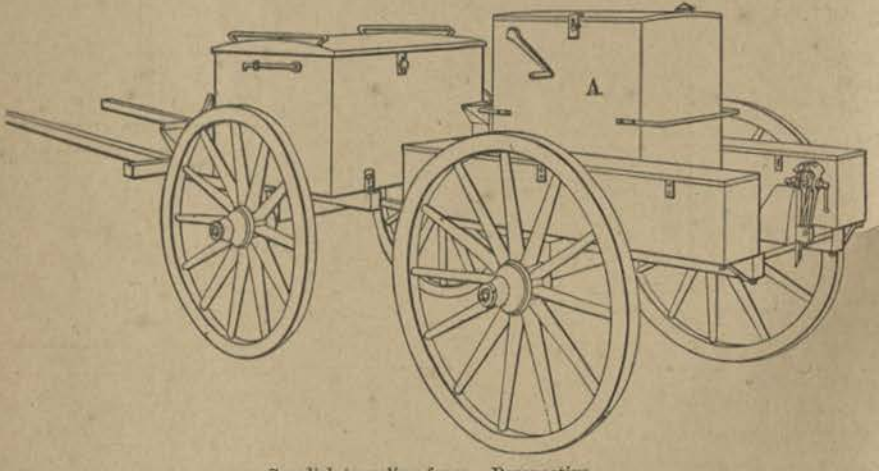
Limber body.

the purpose of allowing a certain vertical flexibility to the system, without affecting the body of the limber. The ends of the limber rest upon blocks of wood overlying the axle, and are held there by a truss-rod passing under the axle and joining the ends of a longitudinal bar beneath the chest and to which the chest is fastened. This truss-rod is flattened where it passes under the axle, and perforated on each side of it, to receive the ends of an iron strap passing over the axle and under the wooden block. Nuts, which are screwed on the ends of the strap, serve to keep it in place. The wooden block is notched to receive the thickness of the strap. A stem runs up from the top of this strap through the bottom of the chest, where it is secured by a nut. Iron straps lead out from the front end of these composite hounds, serving as supports for the foot boards and splint-bar. They terminate in eyes, into which the single trees are hooked. The chest is bolted down at four additional points, front and rear, by means of vertical foot-pieces screwed to its sides. It is provided in front with steps of a convenient form. The pole enters the fork between the splint-bar and rear foot-board above it, and two iron loops joining the parts of the body below. The king bolt passes through

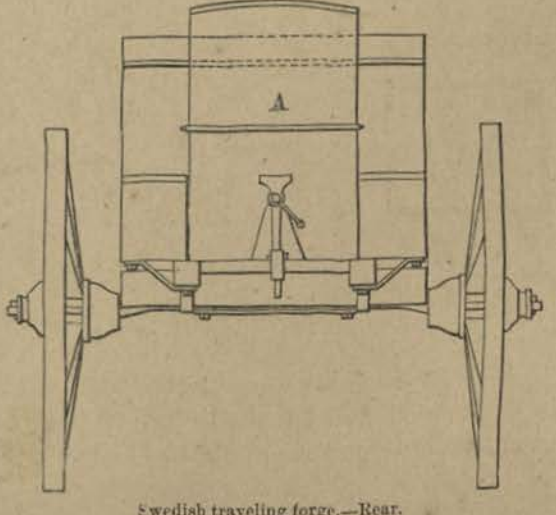
an iron strap joining the bearers in front. An iron stop is screwed upon the pole and abuts against this strap in backing. The limber chest is of wood, bound with iron, and presents nothing new internally. On one side is carried an ax, a shovel in front, the prolonge in rear, and a crow-bar underneath. The foot of the pole prop opens in the form of a fork, by one of the tines of which it is slung. A pole yoke at the front end of the pole consists of a round-iron bar bent at an obtuse angle and passing through a vertical eye-bolt, passing through the hook socket. The ends of this bar terminate in D loops, and are united by a stout wooden brace.

THE SWEDISH TRAVELING FORGE.

No information could be obtained as to the use of the different boxes, compartments, &c., herewith shown. The long boxes on the side are

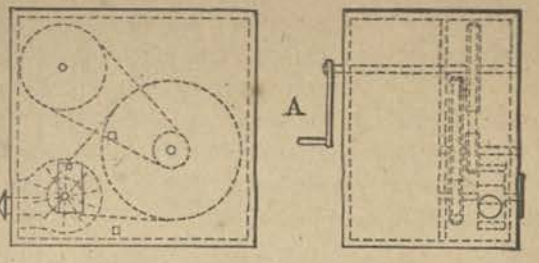


Swedish traveling forge.—Perspective.



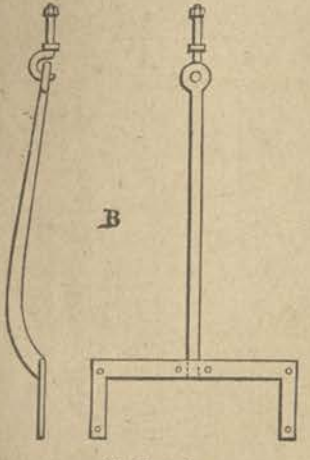
Swedish traveling forge.—Rear.

probably for bar-iron. The fire is urged by a rotary blower. The wheels are very low, and of a different size from those of the other artillery

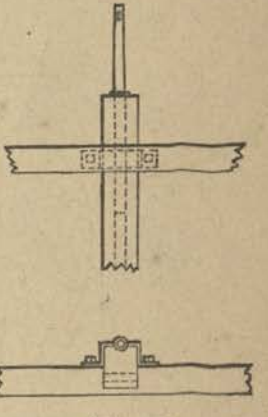


Elevation. Plan.

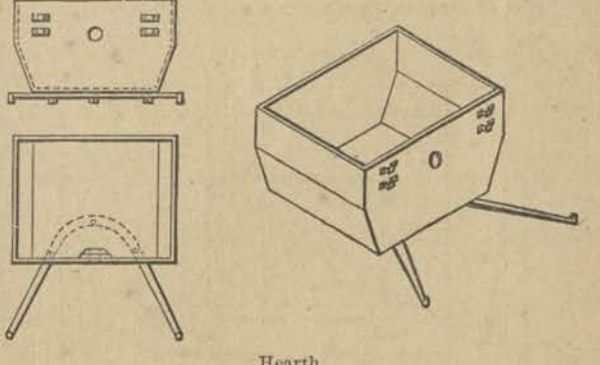
FAN BOX.



Guide pole.

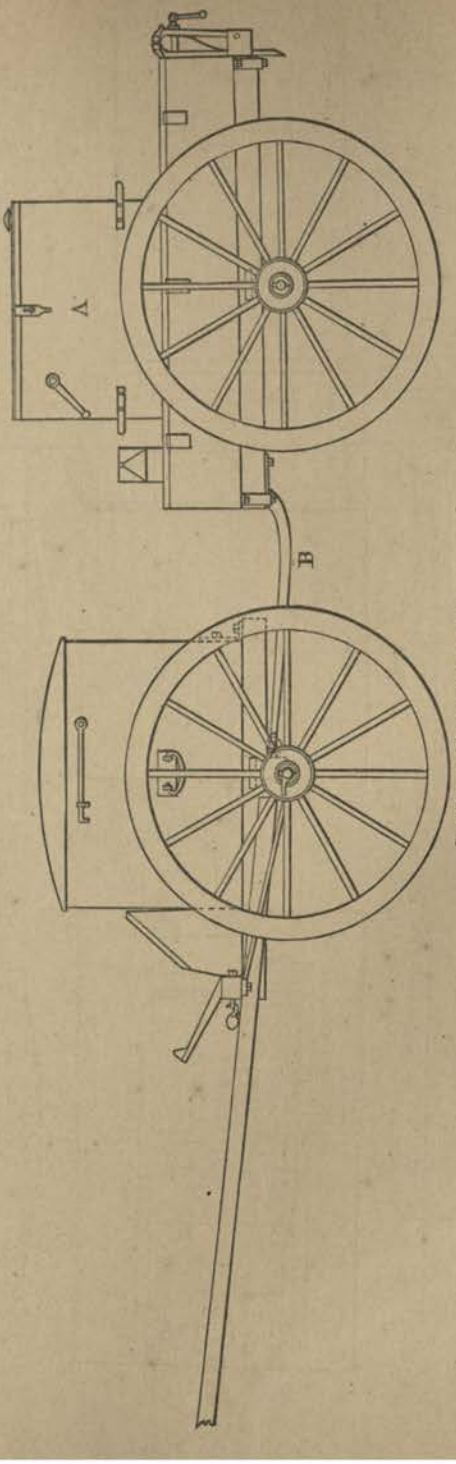


Axle-joint.

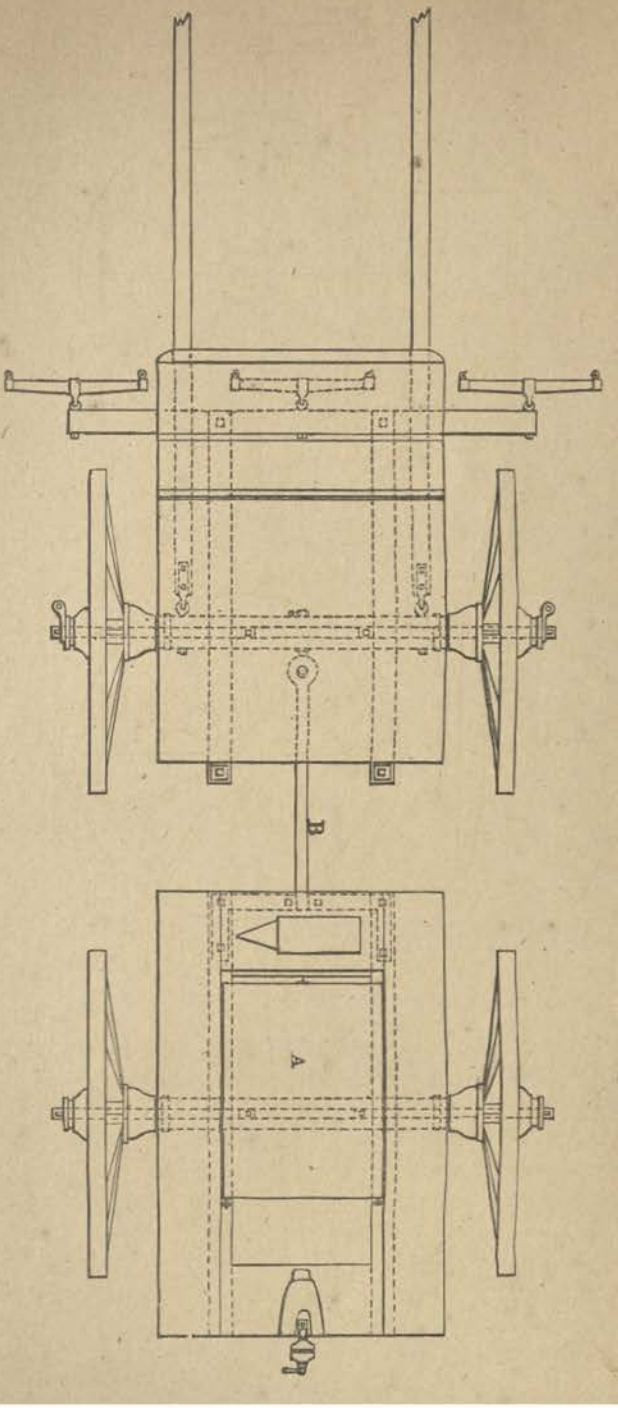


Hearth.

carriages exhibited. The manner of using the forge is apparently this: The fan box A is taken off, and the hearth hooked on the side opposite the crank, so that the holes in the two boxes will match.



Swedish traveling forge.—Side.



Swedish traveling forge.—Plan.

CLASS B.—CANNON AMMUNITION.

SWEDISH CHILLED SHOT.

The Swedish chilled rifle shot are remarkable for the beauty, depth, and regularity of the chilling, several being shown split in two. In the large shot the chilling is confined to the point; in the smaller 16-centimeter shot the chilling runs about half way down the body. The rotation is imparted by copper or zinc buttons, or by two copper rings for breech-loading projectiles (1 inch wide for 16-centimeter shot).

	Price (gold)
12-centimeter with zinc buttons, shell	$2 63
16-centimeter shell	9 21
16-centimeter shot	9 21
24-centimeter shot	20 60
28-centimeter (11-inch) shot studs	28 00
28-centimeter (11-inch) shot rings	32 00

Made of Truspong iron; rear buttons elongated and narrowed.

AMERICAN CHILLED CAST-IRON.

The Baltimore Car Wheel Company, No. 15 South street, Baltimore, show many fine test specimens of chilled cast-iron used in making cast railroad tires, showing that they have probably acquired experience which might become useful in the manufacture of projectiles. Some of their remelted bars made from Baltimore charcoal run in tensile strength to 42,000 pounds per square inch. This company was not alone in this display, many other car-wheel and foundry companies making a similar show of chilled castings.

BRAZILIAN FUZES.

Percussion.—In Fig. 1 the igniting-pin is screwed fast into the base of the cap. The plunger A is hollow, and is held in place by a ring, B, which is fastened to the plunger by a safety-pin and rests against the base of the fuze. On impact the pin is broken and the plunger moves forward out of the ring and strikes against the igniting-pin.

Fig. 2 differs from Fig. 1 only in the shape of the ring B.

In Fig. 3 the plunger carries the igniting-pin, and the fulminate is inserted in the base of the cap.

Time-fuze.—In Fig. 4 F is the metal fuze-plug, within which the wooden time-fuze S is inserted.

The tube G, Fig. 5, is screwed into the head of the fuze and a small plunger with igniter is fastened to it by a pin. At the discharge the pin is broken and the plunger strikes against the fulminate in the head of the wooden fuze-plug, insuring the ignition of the composition should the flame from the discharge fail to accomplish it.

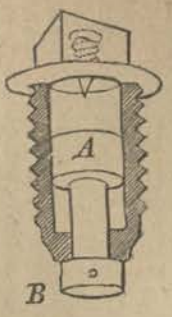


FIG. 1.

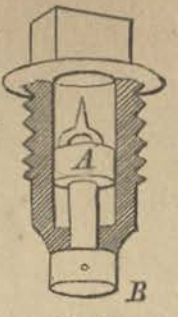


FIG. 3.

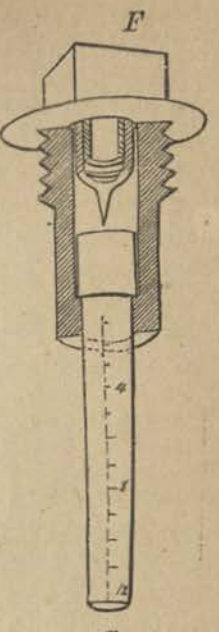


FIG. 4.

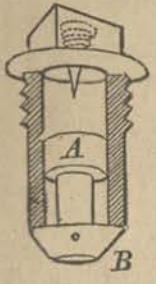


FIG. 2.

FIG. 5.

COLONEL WIEMER'S POWDER (RUSSIAN).

The peculiarity of this consists of its being pressed between *hot* plates in the process of manufacture. The heat is raised sufficiently to render the sulphur slightly soft and pasty. The powder is rendered more dense than by the ordinary method, and is also much less subject to deterioration by wet, &c. I was shown a specimen which had been in water over two months without absolute disintegration. Good English powder fell to pieces in a few days. Cartridges made of this hot-pressed powder are made up in short prisms for gunpowder pile-drivers, and have been extensively used in engineering work along the Neva.

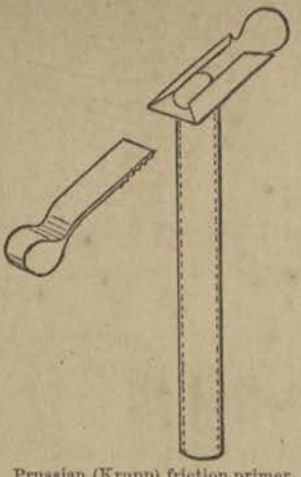
PIGON AND WILKS GUNPOWDER.

Pigon, Wilks & Lawrence, Dartford, Battle, and London, show many varieties of gunpowder for sporting, &c. Their small grain powder is generally characterized by a high glaze and an acicular fracture like that of Hazard's Powder Company. They also exhibit heavy ordnance powder as follows: Pebble, about like "mammoth," in irregular fragments, ¾-inch, 1, and 1.75-inch cube. The large powder is represented by fac-simile imitations highly glazed with plumbago. The cubes are remarkably regular and well defined, the edges being slightly rounded.

PRUSSIAN (KRUPP) FRICTION PRIMERS.

A brass tube 2 inches long is filled with rifle powder and closed at top with fulminate. Near and below the fulminate the tube is choked

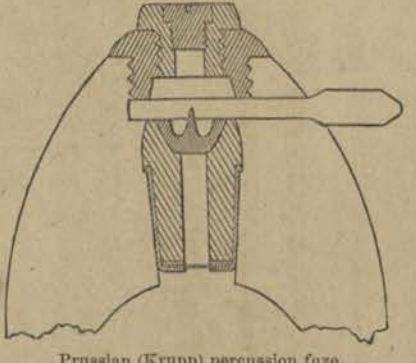
and a flat piece of brass an inch long fitted at one end into the recess and soldered at right angles. A second piece, of less width, doubled over so as to leave a loop at one end, and with the lower surface rough-



Prussian (Krupp) friction primer.

ened, is laid on the flat piece and held in place by having the sides and end of the flat piece lapped over it. A lanyard is attached to the loop, and the friction powder discharged by pulling the roughened surface over it.

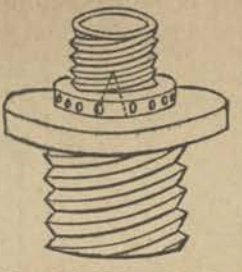
THE PRUSSIAN (KRUPP) PERCUSSION FUZE.



Prussian (Krupp) percussion fuze.

A hollow plunger filled with powder and encased in a washer is fitted in the fuze hole of the shell. The fulminate is contained at the base of the cap which is screwed into the collar. A safety-pin with a weighted head is inserted in a hole in the shell just before firing, and prevents the plunger from touching the fulminate. The bottom of the washer is closed with a diaphragm of cloth. After discharge the pin is thrown out by centrifugal force. On impact the plunger moves forward out of its washer, and the pin in its head strikes against the cap which contains the fulminate. For transportation the cap is replaced by a cork and with the safety-pin carried apart from the shell.

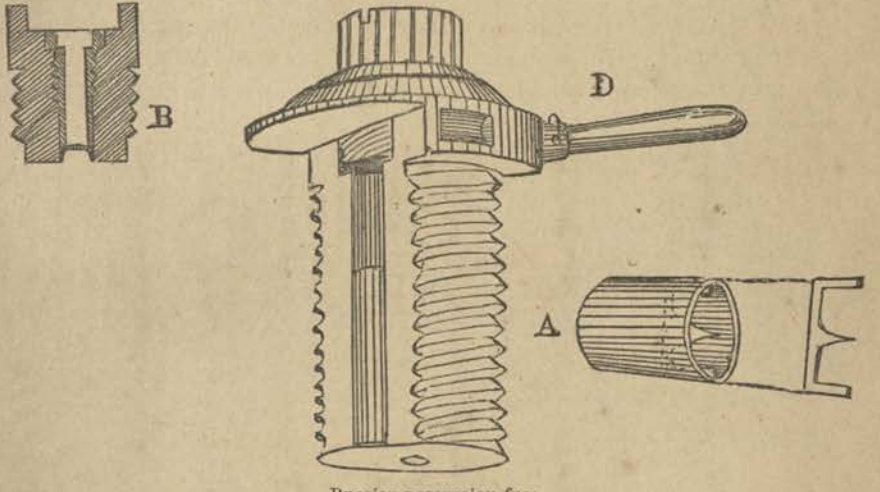
PRUSSIAN (KRUPP) TIME FUZE.



Prussian (Krupp) time fuze.

A loaded plunger is attached to the head of the fuze, which is screwed into place just before firing. The igniting pin is placed in the center of the fuze, and surrounded by apertures through which the flame passes on discharge to the composition, which is held in an annular groove of the usual form.

RUSSIAN PERCUSSION FUZE.



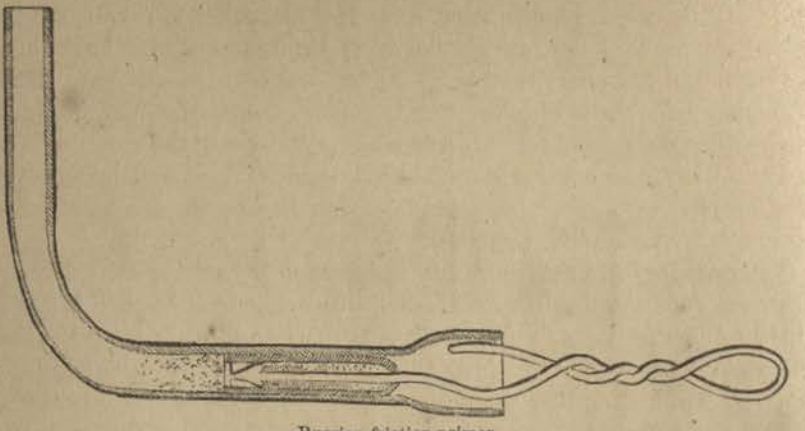
Russian percussion fuze.

The plunger A contains powder. The tube B, which is screwed into the head of the fuze, is filled with percussion composition. Before firing the safety-pin D is removed, and on impact the pin in the head of the plunger strikes against the cap at the base of the tube B, and the flame passes through the bottom of the fuze to the bursting charge.

RUSSIAN FRICTION PRIMERS.

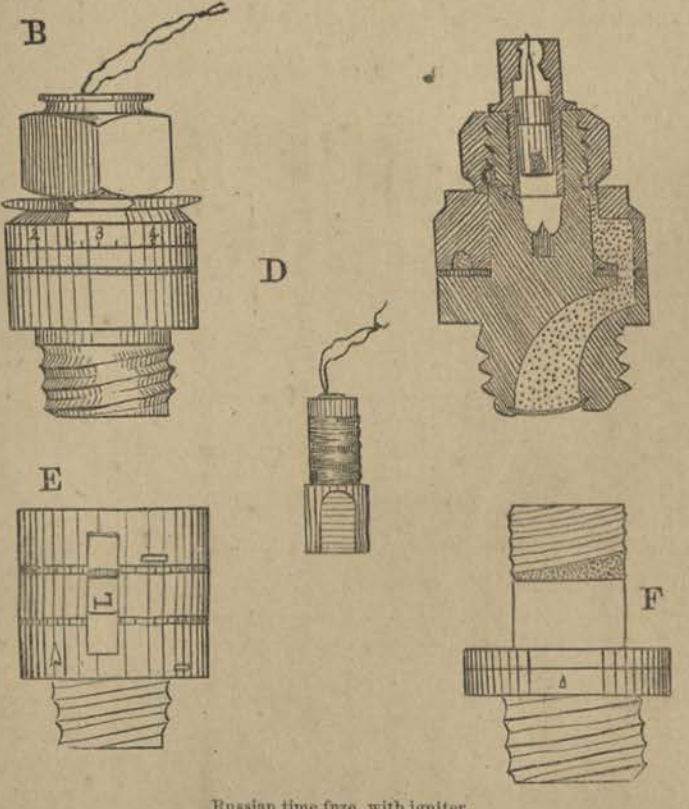
A single bent brass tube is filled for about half its length with rifle powder. In the other portion a wire is inserted with one end of it flattened and barbed, and inclosed in a small tube. This is filled with

the fulminate and is secured by flattening out the longer tube in the rear of it. The barbed wire is pulled through the small tube, and the flame passes back on both sides of it.



Russian friction primer.

THE RUSSIAN TIME FUZE.



Russian time fuze, with igniter.

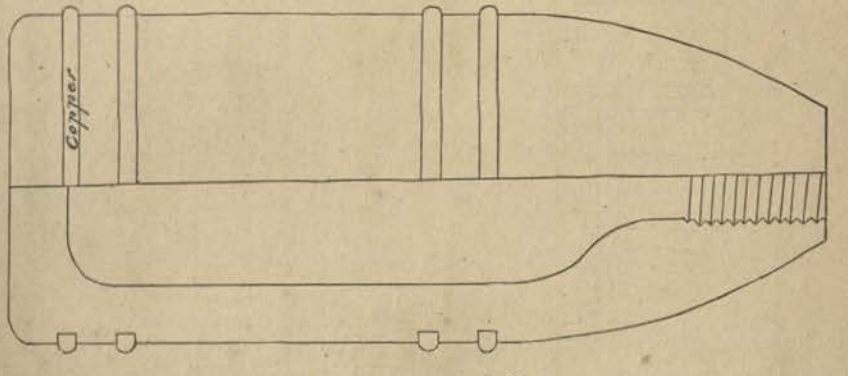
The lowest groove F of the upper screw thread is filled with powder. This is connected at one point with the composition contained in an

annular groove of the usual form, by means of a channel; at another, by the same means with the chamber near the pin on which the plunger strikes. A felt washer, inserted between the groove and the body of the case, is perforated over the magazine to permit the passage of the flame. The plunger contains percussion powder at its lowest point, and is fastened to the top of its case by a small wire. At the discharge this wire is broken, the plunger strikes the pin, and ignites the powder contained in the groove F. By turning the ring which carries the fuze composition, any desired point of it, as indicated by the graduation marks, can be brought over the hole in the felt, and the instant of explosion so regulated.

For transportation the plunger in its tube is kept separate from the fuze case, as shown in B and D, and both closed by corks. These are pulled out before firing and the tube is fitted into the case. To insure a tight fit, the lower part of the tube is wrapped with thread.

A longer burning fuze is shown in E. To set this fuze the slide L is pushed down and the upper ring turned to cover all its graduation marks. It is then made fast to the next ring by running the slide up, and the two together turned until the index points to the graduation mark required.

RUSSIAN 4-POUNDER SHELL.

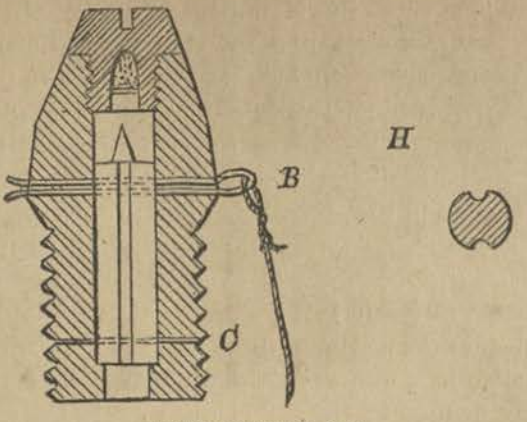


Russian 4-pounder shell.

This shell is strengthened for heavy and light bronze guns.

	Pounds.
Weight of projectile	12.6
Weight of copper rings	0.7
Weight of bursting charge	0.7
Weight of fuze	0.5
	14.5

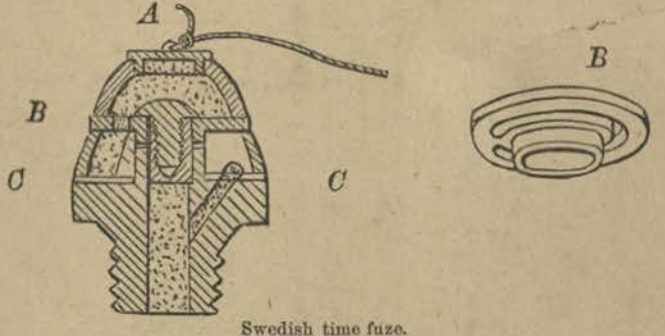
SWEDISH PERCUSSION FUZE.



Swedish percussion fuze.

The percussion composition is contained in a tube screwed into the head of the fuze. The plunger is solid; but two longitudinal grooves (shown in H) enable the flame to pass to the bursting charge on the impact of the shell. Two safety-pins are used; that at B is withdrawn before loading, this other at C is broken on impact.

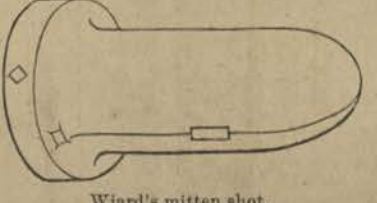
SWEDISH TIME-FUZE.



Swedish time fuze.

The brass cap represented at A is pulled out before loading, and exposes the composition to the flame at the discharge. B is a brass washer inserted between the head and the graduated ring containing the fuze composition. This ring is set before firing, and the flame passes to the bursting charge through a perforation in the felt washer represented at C.

WIARD'S "MITTEN" SHOT.



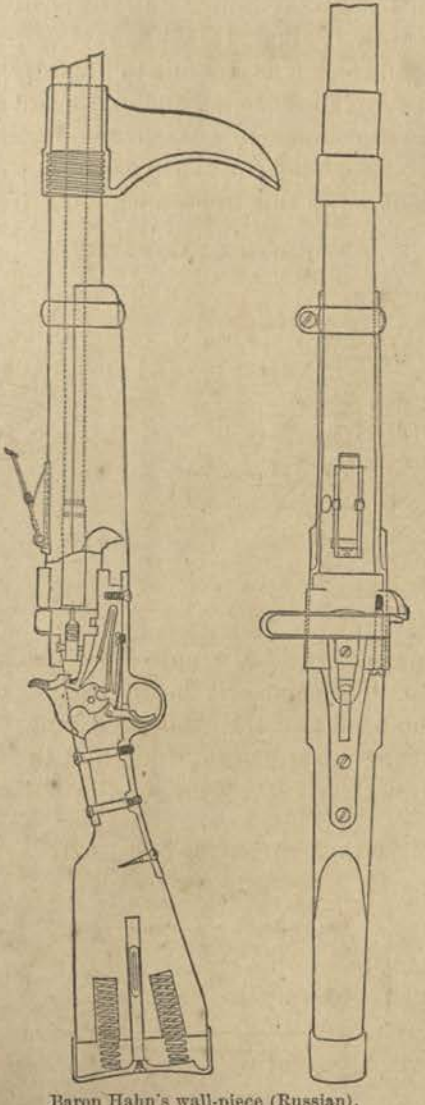
Wiard's mitten shot.

This shot is apparently intended for use in rifled smooth-bore guns where an elongated pointed projectile is required for penetration, and where the strength of the gun does not permit the weight of the projectile to be increased beyond that of the corresponding spherical shot. A long bearing is obtained by the location of the brass studs upon the edge. The point is said to be chilled. Exhibited by the South Boston Iron Company.

CLASS C.—SMALL-ARMS.

BARON HAHN'S BREECH-LOADING WALL PIECE (RUSSIAN).

The breech-block is of the Snider class, opening to the left. The recoil is taken up against the rear wall of a mortise in the receiver. The



Baron Hahn's wall-piece (Russian).

piece is fired by a center lock of the ordinary pattern. The extractor is a lever working upon a vertical axis just beneath the front end of the axis of the breech block. Its inner end engages with the rim of the cartridge at its lowest point. Its outer end projects considerably from the side of the gun, and is fashioned into a beveled surface inclining downward and to the rear. When the breech block is opened its upper side (now the lower) strikes this beveled surface and causes it to move rapidly forward. This brings the inner end carrying the cartridge rapidly to the rear. The breech block is provided with a long horn reaching out to the right, to afford a good hold in opening.

The firing-pin is notched to receive the nose of the hammer. This keeps the breech-block closed. In case the firing-pin projects, it is pressed back by rubbing over the front end of the well in the receiver in closing. The butt plate is countersunk to receive the end of the butt stock, which is let into it about 1 inch. It bears against two spiral springs at its heel and toe. These serve to absorb the recoil. It is connected with the stock by a horizontal pin slotted to receive a transverse bolt.

On the front of the barrel is a heavy curved arm, intended to be hooked over a sand bag laid on the superior slope of the parapet in firing.

All parts of the gun except the barrel, lock, breech block, and a few minor parts, are made of bronze, probably phosphor bronze. This gun is 0.80 caliber between lands and 0.83 caliber between grooves. It has 8 square grooves 0.21 inch wide and 8 lands 0.105 inch wide. I was informed that the Russian Government has 10,000 of these arms in store.

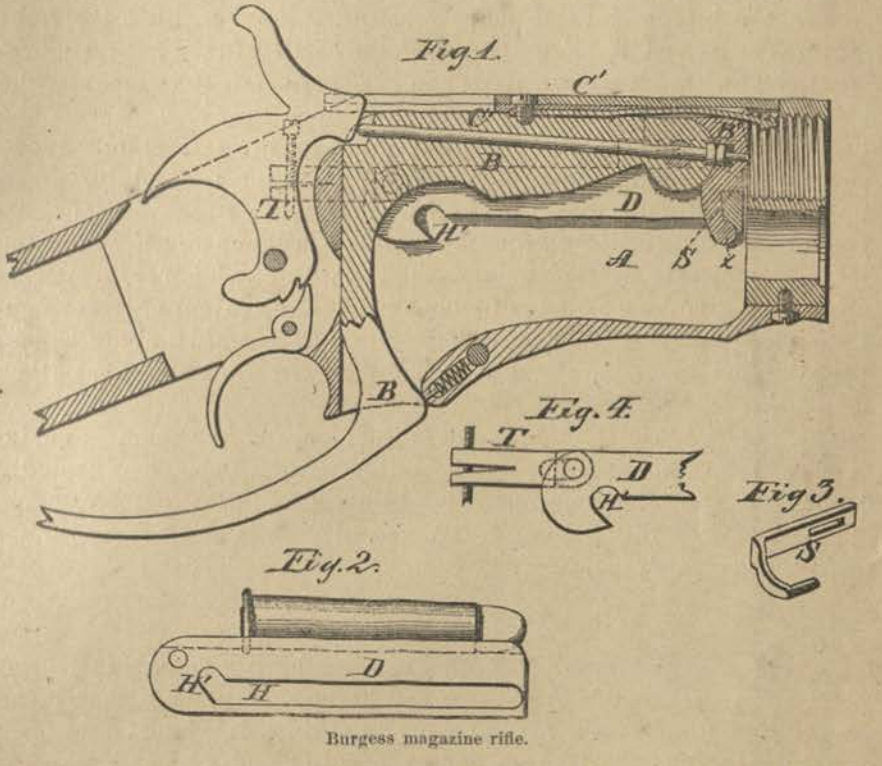
ARMY REVOLVER.—BAYET BROS., A LIEGE.

Bayet's revolver.

The principal feature of this revolver consists in the facility with which the shells can be ejected after firing. To do this the gate is opened; the extractor lever A is then free to move under the influence of a small side spring, B, on the left side of the pistol. This spring,

bearing against the lower arm of the extractor below its center, throws back its upper end, and carries its lower end on the right side into an annular groove formed for its reception on the rear face of the cylinder, embracing that portion of the cartridge head recess of the different chambers nearest the axis. This end is so disposed that each time the pistol is cocked it will lie beneath the rim of a cartridge which is ready for extraction, as shown in the sketch. By then simply snapping the pistol the head of the hammer strikes the upper part of the lever, throwing the lower arm backward and violently ejecting the shell. The chambers can then be reloaded and the gate closed; this automatically brings the extractor lever into place. No provision appears to be made for the case of a loaded cartridge which it is not desired to extract.

BURGESS MAGAZINE RIFLE.



Burgess magazine rifle.

This arm belongs to the class of breech-loaders having the breech closed by a block sliding in line with the barrel and operated by a lever from below. In the figure B, is the block jointed to the solid lever B. B is so shaped that in depressing the hand lever its jointed end will move back in the prolongation of the barrel, carrying with it the block B′, constrained to move parallel with the upper edge of the frame by the slide C resting on the edge and secured to B. This slide carries the extractor and also projects far enough in rear to cock the hammer when pulled back by the lever. The lower part of B′ x projects downward

through a longitudinal slot in the body of the carrier block D, running nearly its whole length from the rear. At its lower extremity B′ is formed in a stud with two arms projecting laterally under the sides of D, or else passing through the slot H in its sides (Fig. 2). D is pivoted at its rear end in an elongated hole formed in the sliding stop T (Fig. 4). S is a sliding stop lying across the face of the breech-block, with a slight longitudinal motion to and from the face in consequence of the elongated hole in the side of S (Fig. 3). The operation of the piece is as follows: By depressing the lever the block B′ is drawn directly backward, until the transverse arms x strike the rear face of the notch H′. When this occurs D is forced to turn downward around its axis in T, until it comes opposite the mouth of the magazine. Here it receives a cartridge in the usual way, the cartridge being kept from going too far backward by the stop S. Then the lever is closed. This causes the breech-block to move forward, x now striking the front surface of the recess H′ and causing the carrier to rise. The movement of the breech-block carries the cartridge into the chamber, the arms of x keeping the carrier level as soon as they emerge from the notch H′. This device is equally important for the extraction.

The piece is fired by an ordinary center lock, the recoil being taken up by the bodily movement backward of the lever B against its abutment on the frame. The firing-pin is in two sections on account of the joint. The arm is used as a single loader by withdrawing T (Fig. 4); this allows the carrier to slide bodily backward to the extent of the elongation on T when struck by x at H′. By pressing T forward it abuts against the joint pin and compels D to turn downward when struck at H′ as described.

The stop S, cover C, and a lip over the mouth of the chamber are intended to prevent the accidental escape of cartridges when being rapidly transferred from the magazine. The arm appears principally valuable from its adaptability to long cartridges.

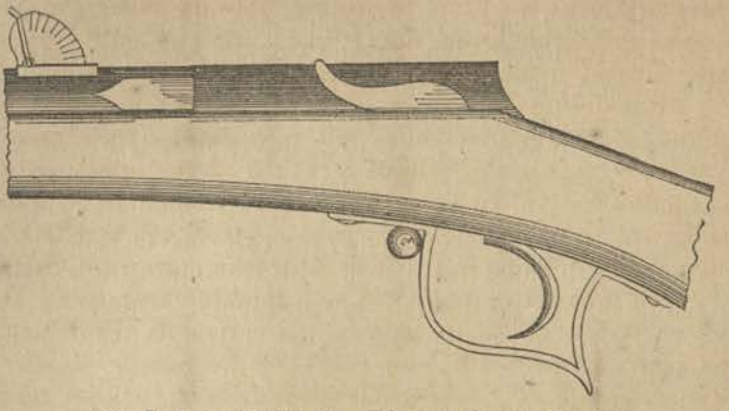
A. Burgess, Oswego, N. Y.

BURGESS MAGAZINE RIFLE NO. 2.

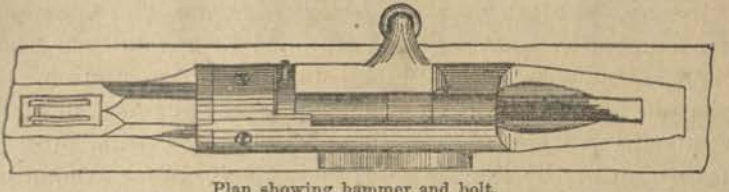
In this gun the breech-block revolves on a horizontal axis in rear at right angles to the axis of the gun, and in the same plane with it, being moved by a thumb piece from above. In opening it a stud on the back of the breech-block strikes the carrier lever in front of its axis, which is considerably to the rear of that of the breech-block. This throws down the front end of the carrier. In falling a hook on its rear portion engages with a stud on the back of the breech-block by which it is raised. When the block is closed there are several other points of detail in construction. Without raising the question of priority, it may be said that this arm resembles the Freeman magazine gun already reported on by me.

A. Burgess, Oswego, N. Y.

BREECH-LOADING RIFLE, BY CAPT. P. J. INDE BETOU, OF THE DUTCH SERVICE.



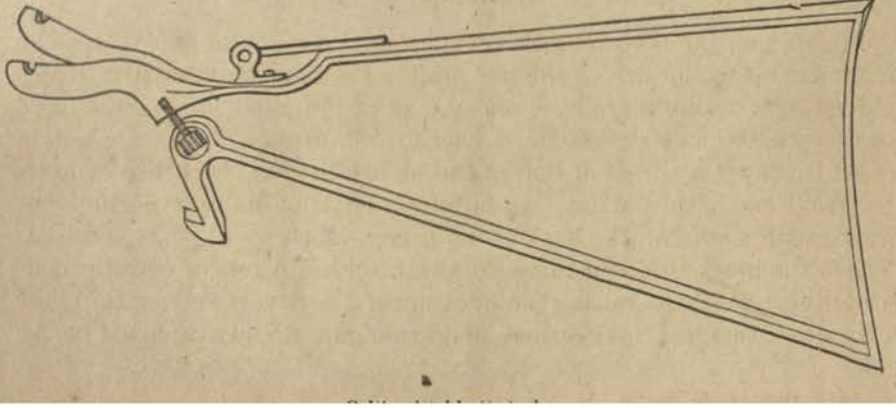
Capt. P. J. Inde Betou rifle.—Side view showing hammer.



Plan showing hammer and bolt.

A bolt gun with an independent hammer on the left side of the system, animated by a flat spring beneath the receiver. A lug beneath the handle section of the breech bolt has a spiral-shaped surface on its right side, and in opening operates a corresponding cam on the axis of the hammer. The firing-pin is independent, and retracted by a spiral cam on the bolt. One point claimed for this gun is that the firing-pin is not in line with the eye of the firer. The gun can be cocked or placed at half cock independently of the bolt.

The Beaumont gun, of which a sample is on exhibition in the Ordnance Section, is the arm generally used in the Dutch army.



COLT'S PISTOL BUTT-STOCK.

The jaws on the stock pass on each side of the frame and engage with the head of the hammer-screw, which is made of extra length. By turning up the milled screw-head, the pistol is clamped between the hammer-screw and the barbed hook beneath.

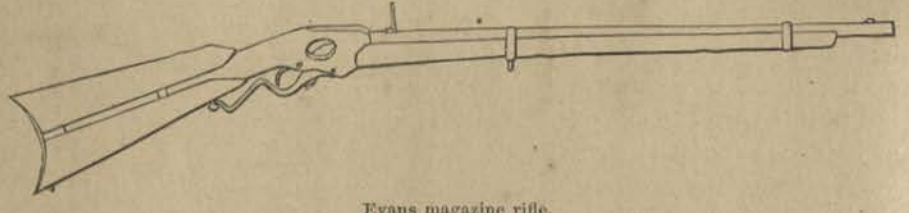
DUTCH GOVERNMENT SMALL-ARMS FACTORY AT DELFT.

Stand made with two heavy brass rings surrounding a central spindle. These are notched at six points of their rim and on each side of the notch contain small holes for a bent wire retaining staple. Between each pair of guns the characteristic bayonet and its scabbard are shown crossed. The whole five mounted on a pedestal about 3½ feet high, containing specimen gauges.

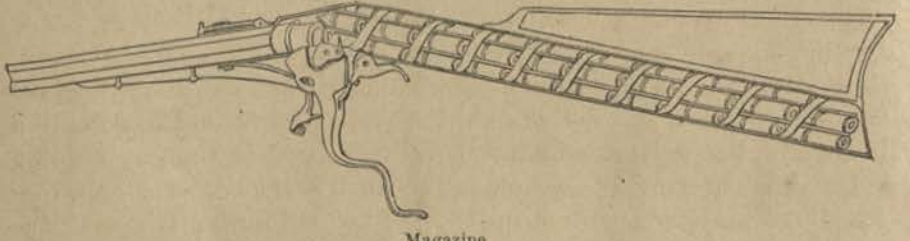
SMALL-ARM GAUGES (DUTCH).

Dutch gauges are on the same principle as the ordinary notched gauges in use in the United States, somewhat rude, and imperfect of finish. The length of the stock gauges and their shape would indicate that the stock was worked out by hand. Although using plug gauges for the chamber in the service gun, the principle of sectional gauges does not seem to have been applied.

THE EVANS MAGAZINE RIFLE.



Evans magazine rifle.



Magazine.

This consists essentially of a fluted cylinder in the butt stock revolving within a fixed helical scroll, the pitch of which is equal to the length of one cartridge. By depressing the lever the breech is opened, the empty shell extracted, the hammer cocked, and the fluted cylinder

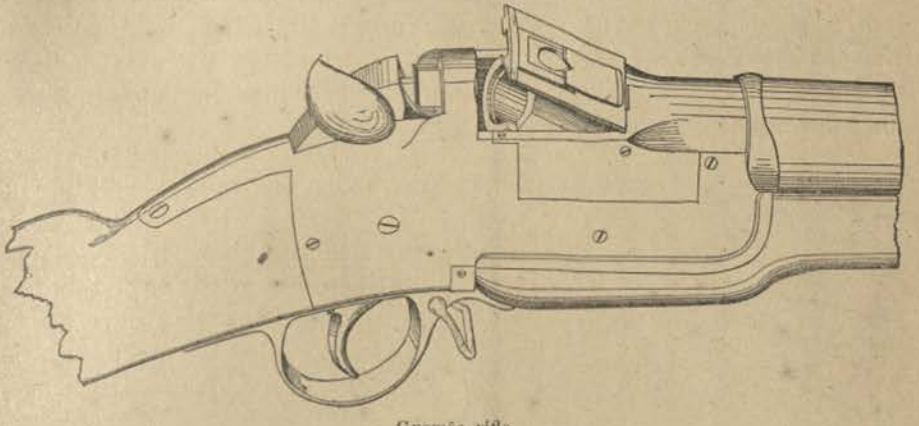
given a part turn by which a fresh cartridge is thrown out in front, ready to be shoved into the chamber when the breech is next closed.

The shell is drawn back by an extractor sliding over the face of the breech-block from below as the lever is depressed. A rapid impulse given to the projecting front end of the fluted cylinder as it makes its part revolution serves to eject the shell through a hole in the right side of the frame.

The magazine is filled by dropping in the cartridges through the butt plate, working the lever meanwhile. It can be used as a single loader by limiting the movement of the lever, putting the cartridge directly into the chamber by hand. The main feature of the system is the magazine in which the cartridges are carried in large quantities and not resting upon each other. The center of gravity is also well to rear.

This arm is made by Merwin, Hulbert & Co., New York, at a cost for the musket of $40. The magazine contains thirty-four .44 caliber cartridges about 1.5 inches long. Its weight with 30-inch barrel is 9 pounds.

GUSMÃO RIFLE (BRAZILIAN).

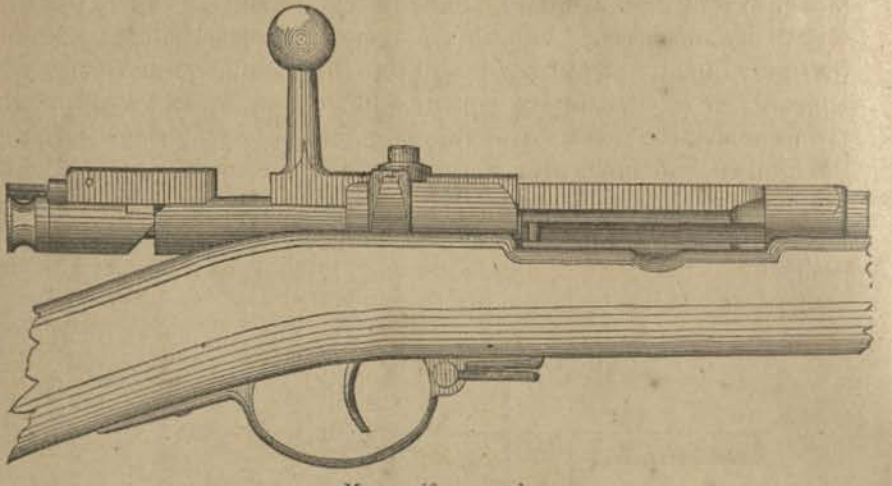


Gusmão rifle.

The arm is opened by cocking the spoon shaped handle shown in the sketch. The obverse of this handle is hollowed out and checkered. This operation causes a sort of split chamber, pivoted at its forward end, to rise within the well of the receiver, as shown in the sketch; a lid covering the well is simultaneously thrown up in a slanting position and a slide covering a peep-hole in the lid is dropped. The breech is closed and the gun simultaneously fired by pulling the trigger. The lower part of the split chamber has a slight motion to the rear. This is supposed to be made with reference to the extraction, the quick throw to the rear being imparted through the hammer. No opportunity was afforded to examine this arm in further detail. The barrel up to the lower band is sheathed with wood to protect the hand from burning.

MAUSER RIFLE (GERMAN).

The arrangement of the Mauser for opening resembles closely that of the Chassepot, from which it was probably derived. By turning up the handle on the side, a wedge-shaped projection on the face of the cocking piece is made to bear against the inclined side of a corresponding notch in the body of the bolt. The cocking piece is consequently forced backward against the pressure of the main spring, until the point of the



Mauser rifle—opened.

wedge is free from its notch in the bolt. The continued revolution of the bolt brings the wedge away from this notch and allows it to bear against the flat portion of the rear end of the bolt, as shown in the sketch. At this moment the base of the handle is in line with the slot in the rear portion of the receiver and the entire bolt may be drawn back. The operation of the recoil block and extractor closely resemble those of the Mauser. (Ordnance Memo. 15, Report of Chief of Ordnance, 1873).

The stop screw and washer above the bolt strike the back of the receiver and keep the bolt from going too far. It is closed by reversing the former movement of the bolt. In turning down the handle the notch in rear of the bolt is brought opposite to the wedge-shaped projection in the cocking piece, but the cocking piece is prevented from moving forward by engaging on its lower surface with the upper end of the sear bolt. As the bolt is turned down into place, it is given a slight motion forward by striking the inclined surface in which the front wall of the receiver is formed. This arrests its motion gradually, and prevents its giving the cartridge a sudden shock in case any obstruction should prevent its free entry into the chamber.

Fired.—By pulling down the sear bolt through the trigger. The cocking bolt and firing pin are screwed together. The latter is consequently retracted by the operation of opening.

Extractor.—By a single-leaved spring hook extractor closely resembling that described in Ordnance Memo. 15, Report Chief of Ordnance, 1873.

Ejection.—None is provided, the arm being apparently canted to the right to roll out the shell.

Half-cocked.—A short cylindrical pin flattened in front passes longitudinally through the cocking piece, and when the arm is closed enters a corresponding recess on the upper surface of the bolt in rear. By means of a large flat square handle in rear, occupying nearly the entire length of the cocking piece, this pin may be turned so that the round portion will enter the groove and keep the cocking piece from moving forward; or so that the flat portion will be next to the groove, so that the piece may be fired. A little cam is formed on the lower surface of this pin, so that in turning it presses back the cocking piece slightly, compressing the mainspring, and is secured in whatever position it may be placed. This description was prepared from a rifle imported from Germany to complete the exhibition of small-arms made by the Ordnance Department.

MERWIN, HULBERT & CO., REVOLVER.

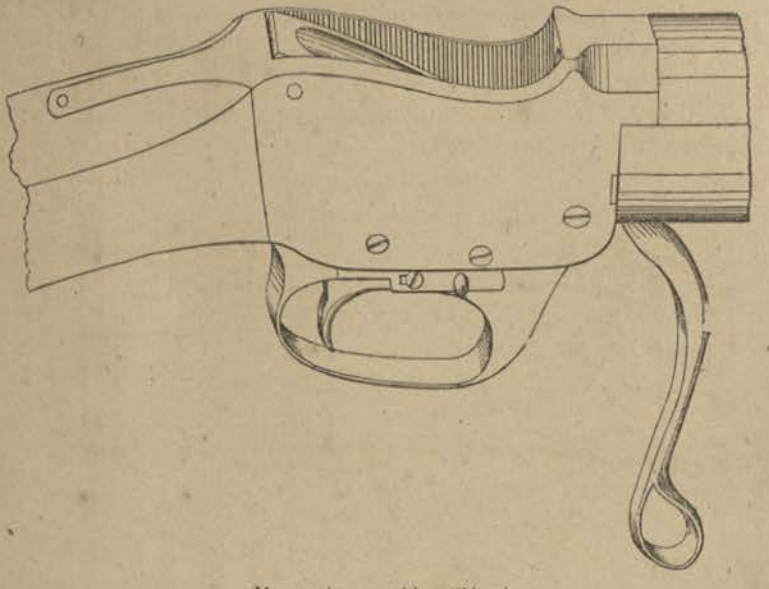
Merwin, Hulbert & Co., revolver.

This revolver is opened by sliding the barrel and cylinder bodily forward along the base pin. A sliding thumb-catch beneath the lower strap of the frame holds the barrel when closed, engaging with the notched stud beneath the barrel.

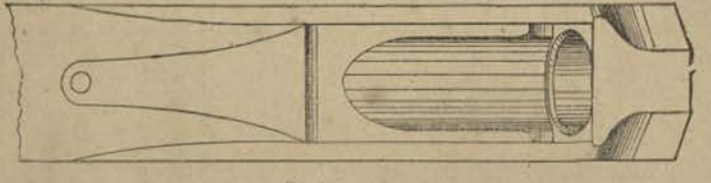
In opening the revolver the cartridge shells are ejected simultaneously, being held back by a circular ring on the recoil face about the foot of the base pin which overlies their rims. The cartridges are inserted from the right side, as in the Colt revolver, but through a sliding gate. This brings their rims in rear of the fixed ring above mentioned. A lever spring-catch on the side of the barrel frame engages with a notch in the forward end of the base pin, and keeps the barrel from coming off when the pistol is opened. By pressing the projecting end of the lever, the catch may be released, and the barrel and cylinder removed for cleaning.

MORAES-ANCORA MUSKET (BRAZILIAN).

By depressing the lever beneath the trigger-guard, the breech is caused to fall as in the Peabody. This action simultaneously cocks the hammer, which is placed very much as in the Westley-Richards arm, upon the same axis as the lever, the top of it being thrown backward. It is probably operated by a flat mainspring within the receiver. The



Moraes-Ancora rifle. Side view.



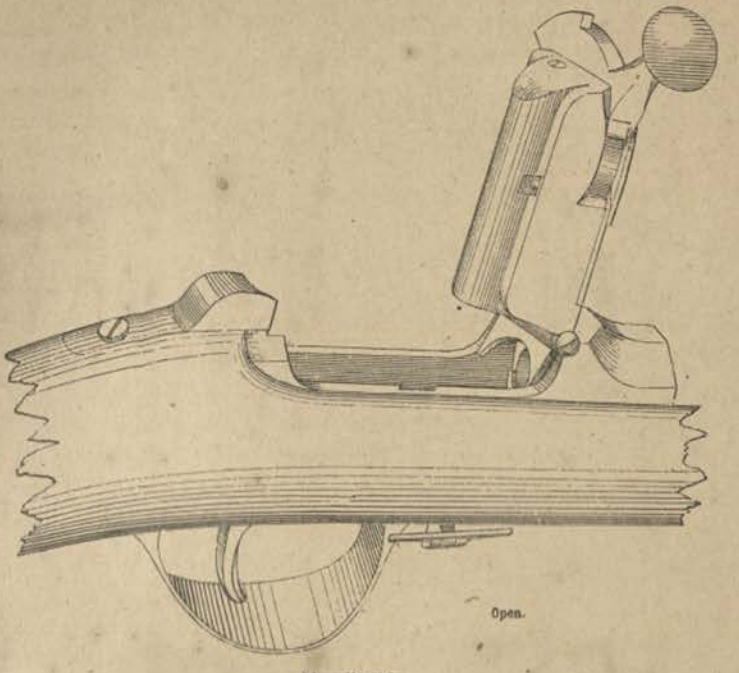
Breech open.

extractor is apparently of the Peabody class, provided with only one branch on the left side of the chamber. The barrel is sheathed in wood up to the lower band. It is understood that this is the standard arm of the Brazilian service, being an alteration of the Westley-Richards system by the director of the Imperial Arsenal.

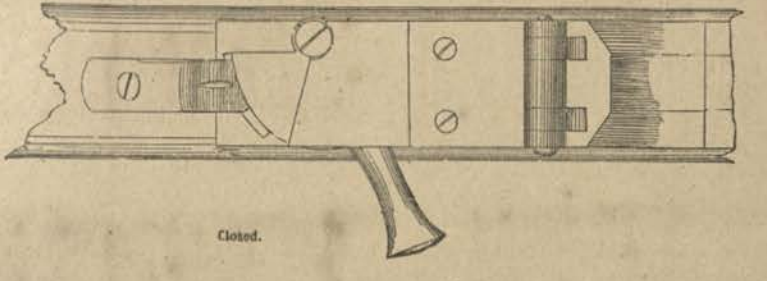
THE MOSELLI RIFLE (BELGIAN).

The breech-block opens like the Springfield. It is locked when closed by a sectoral-shaped piece hinged to it in rear upon a vertical axis. A portion of the rim of this sector enters a horizontal notch in the rear face of the receiver and serves to keep the piece locked when closed. The rim to the right of the receiver is cut away, so that when the sector is caused to revolve to the left by means of the horizontal handle

on the right, the block is free to open. In opening, the sector cocks the piece by compressing a spring within the body of the breech-block, which has hitherto acted to keep the block closed. The hammer, or striker, is held independently of the sector by a sear within the block,



Moselli rifle.



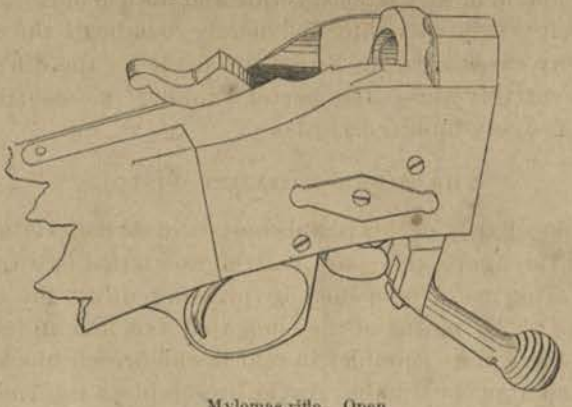
the end of which projects slightly to the right. When the trigger is pulled, a second sear on the outside of the right wall of the receiver trips the sear in the block and fires the piece.

The extractor is as in the Terssen gun.

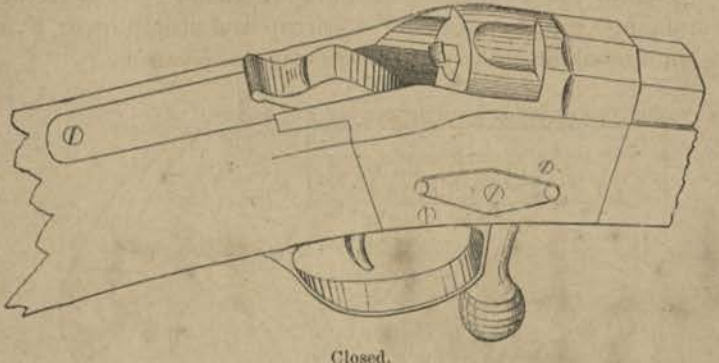
MYLOMAS RIFLE (GREEK).

Opened by depressing the lever in front of the guard. This has a solid claw in rear, which pulls down the breech-block, the latter sliding like the Comblain, nearly at right angles to the barrel. In its descent it strikes the extractor pivoted below the barrel and rocks its

upper end backwards. The firing-pin projects to the rear far enough to require the hammer to be half-cocked before opening the gun. A flat spring, with wedge-shapped head, lying beneath the handle, catches



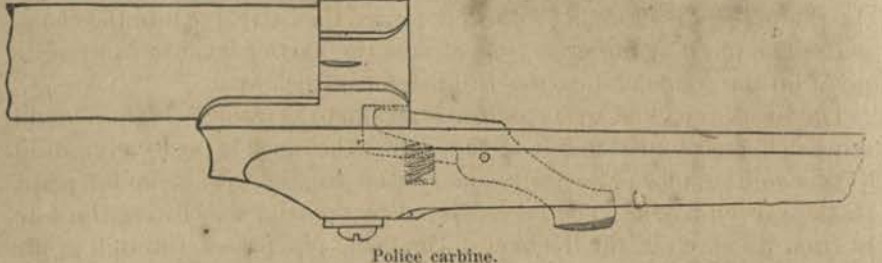
Mylomas rifle. Open.



Closed.

in a notch just in front of the guard and keeps the breech closed. In the carbine the knob-like handle projects laterally to the right. This gun, of Greek invention, is made in Belgium.

POLICE CARBINE (DUTCH).



Police carbine.

Lower band.

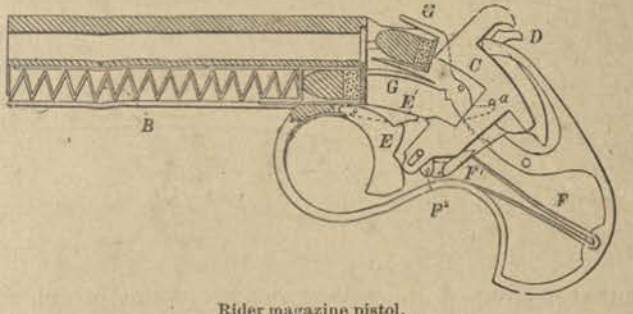
This is a carbine provided with a small bayonet about 12 inches long. By pressing the spring catch and turning back the bayonet it engages over the side-lip on the lower band by its natural spring. It is said that this bayonet proves valuable and is frequently used by the police.

REAR SIGHTS ON FINE ENGLISH RIFLES.

These are generally arranged with a wide bar, having either a very fine narrow notch, or an extremely wide and obtuse one. In the former case the notch is evidently intended merely to indicate the middle of the bar. In many cases separate leaves are made for the different ranges, placed consecutively along the barrel, running in one case up to 600 yards, one for every hundred yards.

THE RIDER MAGAZINE PISTOL.

The main peculiarity of this pistol consists in its compactness, having, as seen from the figure, the spare cartridges carried in a tube beneath the barrel. The pistol is opened by pressing down the comb of the breech-block C. By means of the elongated axis hole in its lower end, this permits the square shoulder in rear of the breech-block to descend from its abutment in the frame. As the breech-block is turned backward it presses against and cocks the hammer D; when released, the pressure of the mainspring F, by means of a stirrup and stump lever F^1 and F^2, throws the breech-block forward to its original position.



Rider magazine pistol.

In opening the breech, a transverse pin *a* in the breech-block strikes the tail of the forked carrier-lever G, and raises a cartridge from the magazine B. A spring, G^1, keeps the succeeding cartridge from issuing. As the breech-block falls forward, it carries the cartridge into the chamber. The pin *a* at the same time strikes the carrier-lever in front of its pivot on the frame and carries it down for a fresh load.

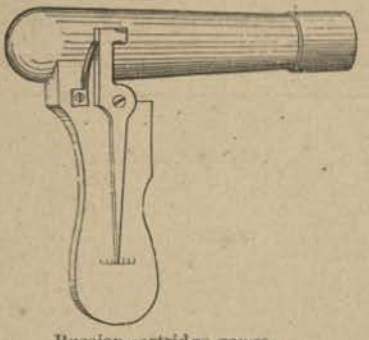
The block is locked by its abutment against the frame. If this should not be effected by the action of the spring, the block is positively raised by the contact of a projecting point on the trigger with a similar point on the breech-block. The piece is fired by the trigger E lifting the sear E^1 from its notch in the hammer. The firing-pin passes through a slit in the face of the breech-block.

The cartridge is extracted by a sliding extractor operating essentially like that of the Remington rifle. It is ejected by a quick upward movement of the upper arm of the carrier-lever. The thumb-piece of the breech-block is bored through to form a sight. The piece can be carried

at the half-cock by pressing down the breech-block when the hammer is down.

The compactness of the piece is its main recommendation. It might be adapted to the use of long cartridges, though this is doubtful, for reasons similar to those operating against the alteration of the Spencer rifle.

RUSSIAN CARTRIDGE GAUGE.



Russian cartridge gauge.

The Russian Government exhibit some very fine specimens of accurate workmanship in gauges for parts of small-arms, viz: 41 plug and ring gauges from 0.6 inch to 0.52 inch, with uniform increment of 0.0005 inch, also two taper plugs, 10 inches long, upon which, when strung, the ring gauges fit themselves with extremely uniform distances. These gauges are said to be made to within 0.0001 inch. There are also standard inch and half-inch prisms, made of glass, to prevent variations from change of temperature. The entire set of gauges for both small-arms and cartridges is essentially like that adopted in the United States. For verifying the position of the throat and shoulder of the chamber, there are used index gauges as represented in the sketch.

C. LANCASTER'S INCLINED BUTT-STOCK.

Lancaster's inclined butt-stock.

C. Lancaster, besides his well-known twist oval bore, exhibits a double shotgun with the stock bent to the right, so that the axis of the barrels may be more immediately in front in firing.

RUSSIAN COMPOUND IMPLEMENT.

The Russian compound implement consists of a steel bar about 6 by $\frac{3}{4}$ by $\frac{3}{16}$ inches, one end of it being formed into a screw-driver. A slot about 4 by $\frac{3}{8}$ inches is cut through it longitudinally. At one end of this slot is

hinged a T-shaped piece, the stem of which forms the small screw-driver. The stem near its junction with the head of the T is enlarged, and has a screw cut upon it; upon this screw is fastened a brass wiper stem, which can be detached and screwed upon the end of the ramrod. The project-

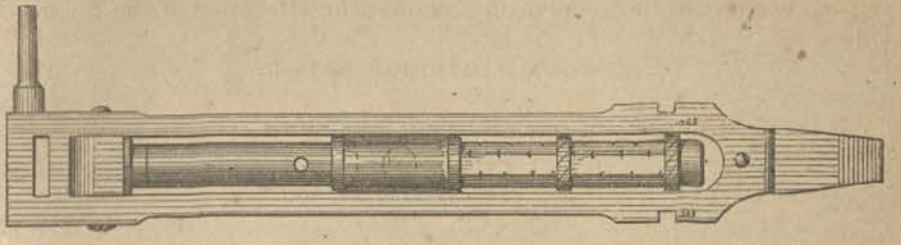


Fig. 1.—Closed.

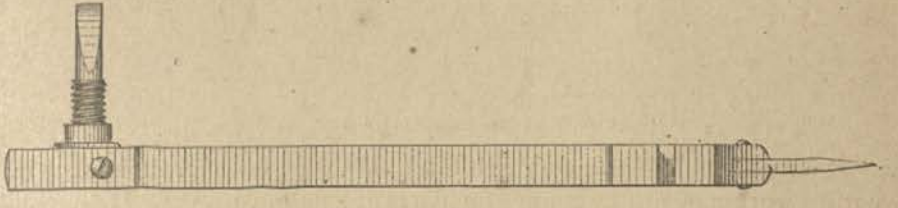


Fig. 2.—Small Screw-Driver in use.

Fig. 3.—Cleaning Rod.

Russian compound implement.

ing pin is meant for unscrewing the ramrod, the notches in the head are for ganging the projection of the firing-pin. The tool appears quite expensive. The body of the implement is braced across mid-length of the slot.

SHARPS SELF COCKING RIFLE.

In closing the breech, the link between the lever and the tumbler catches against the shoulder of the tumbler and presses it back, bring-

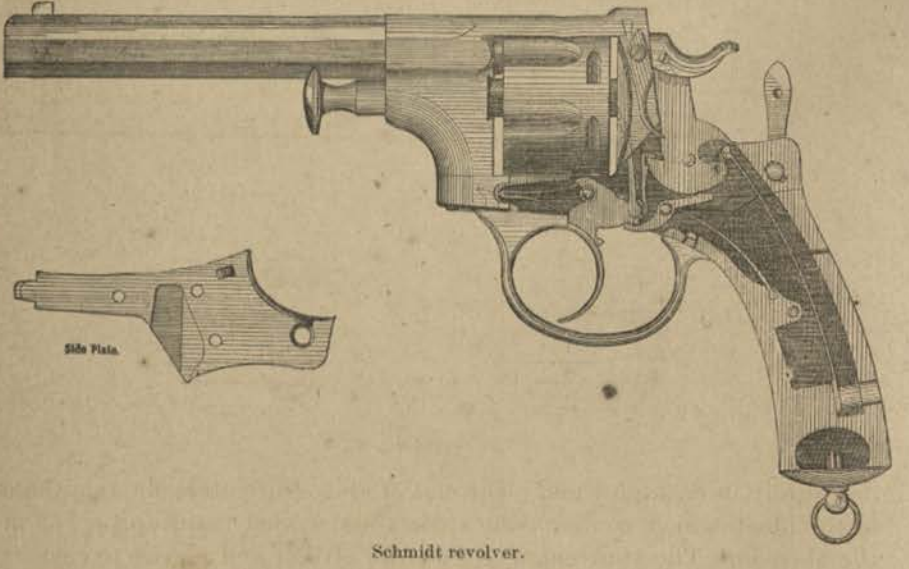
Sharps self-cocking rifle.

Section.

ing the hammer to the full cock. The hammer can be cocked independently by hand. Sharps Rifle Company, Bridgeport, Conn.

SCHMIDT REVOLVER (SWISS).

In opening the revolver the cylinder and barrel revolve together upon a vertical axis a little to the right of the butt of the barrel. When closed a rectangular tenon on the upper part of the recoil shield enters a horizontal notch in the underside of the barrel strap, and is confined there by a swinging thumb-lever on the left side of the frame. The axis pin, with which this lever revolves, passes through the frame in front



Schmidt revolver.

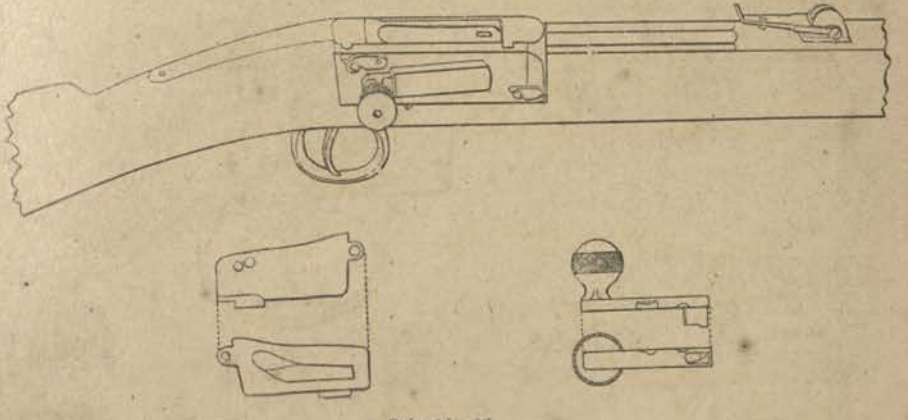
of the face of the hammer, where it is slightly cam shaped. In consequence, the pressure of the hammer serves to keep the thumb-lever in place when the piece is closed; and also in turning the lever to open the piece the firing-pin is retracted from the face of the cartridge and held at the half-cock.

The extractor is star-shaped, as in the Smith & Wesson revolver. Its stem issues beneath the barrel, and terminates in front in a large button. By simply pressing on this button with the thumb, the cartridges are simultaneously extracted if they offer no great resistance to moving. A spiral spring draws the extractor back. The pistol is self-cocking.

The apparatus for dismounting is very simple. By turning up a lever on the right side of the frame, a screw thread on the shaft attached to it within is detached from a corresponding recess in the side plate, so that the latter may be unhooked from its notch in the forward portion of the frame, and removed. The corresponding side piece of the stock may then be removed, being held in place by the side plate, and a pin in the butt which enters it from below. The attachment of the trigger-guard is noteworthy. It is simply sprung into the frame. The head of the rear stud is T-shaped, to enter a recess inside the side plate. (See use with holster butt, p. 874.)

SCHMIDT RIFLE (SWISS).

The breech-block operates very much as in the Smoot-Peabody system. (See Report of Chief of Ordnance, 1873.) It is operated by a longitudinally sliding bar on the right side of the receiver, provided with a good-sized knob. A stud on the inside of this bar passes through a slot in the side of the receiver, and enters a groove in the side of the breech-block, curved upward to the rear. The reciprocating motion of the bar therefore causes the front of the block to rise and fall, holding



Schmidt rifle.

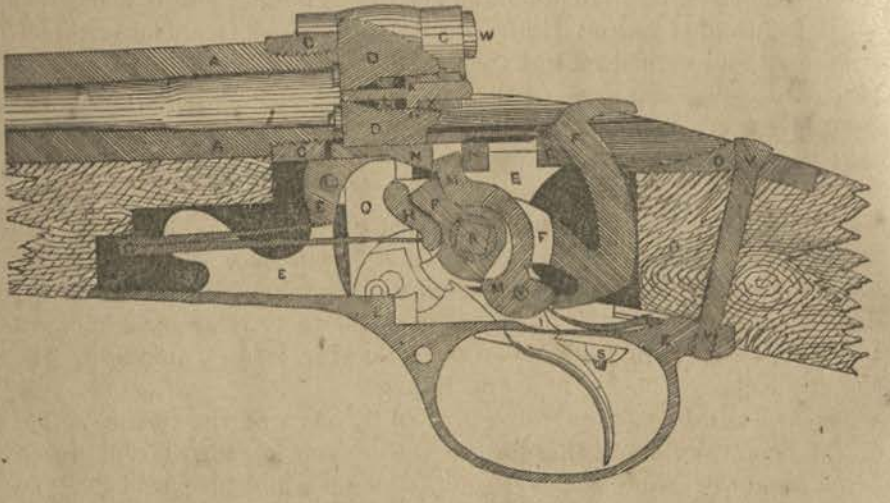
it securely in each position. The end of this stud enters an axial hole in the block which contains the striker and coiled main spring, as in the Martini. The stud engages with the striker and serves to cock it in opening the piece. The striker is held against the pressure of the main spring by a flat spring sear lying beneath the receiver, and having a projecting lip in rear underlying the nose of the trigger. The extractor is single, of the Peabody type. The blow of the falling block is first received upon a flat spring, the front end of which is let into the

vertical arm above the horizontal arm of the extractor. This serves to start the cartridge slowly by reducing the shock of the blow.

The sliding bar is held at each end of its stroke by flat springs with curved ends entering corresponding notches in its edge. The entire right side of the receiver comes off at pleasure, being fastened by little swinging clamps. The axis pin is solidly fastened to the left side of the receiver. It will be observed that the stock surrounds the mechanism on two sides only.

This arm was devised by Colonel Schmidt, director of the State Arsenal, Switzerland, the inventor of the ingenious revolver elsewhere described.

SOPER RIFLE (ENGLISH).



Soper rifle.

A, barrel; B, stock; C, breech shoe; D, breech block; E, lock-box; F, cock; G, mainspring; H, swivel; I, main trigger; K, striker; L, bolt; M, extracting lever; N, extracting slide; O, connecting rod; P, tumbler; R, shaft; S, trigger; T, trigger spring; U, side screw; V, tangent screw; W, breech-block pin; X, nipple; Y, trigger pin; Z, side plate.

The breech block belongs to the Snider class, working on horizontal axis on the right side. It is opened by depressing a side lever on the right side of the gun. The operation of this lever downwards throws open the breech, cocks the hammer, and extracts the cartridge shell. By raising the lever the breech is closed, and locked by a bolt traversing the breech block horizontally at right angles to the axis of the barrel. The end of this bolt is positively thrown into a notch in the side of the well of the receiver by the raising of the side lever, and the intermediate action of the connecting rod. This bolt also automatically retracts the firing pin before opening.

The breech trigger performs two functions; it engages against the back side of the tumbler when the piece is open, and keeps the breech-block from falling; it also serves, when the breech is closed, to keep it from opening from accidental pressure on the lever, unless the breech

trigger is purposely pressed upward, or until the main trigger is pulled in firing. In the latter case the cross arm S of the breech trigger is raised, throwing out its forward end from its notch in the tumbler. When at half cock the gun can neither be opened by the lever nor by direct action on the block, nor can the hammer be let fall.

The breech block D is mounted on a pin, W, which is fixed parallel to the bore of the barrel, so that the block swings freely in a plane at right angles to the bore, thus allowing a cartridge to be inserted and retracted with its axis in line with the axis of the bore.

On reference to the sketch, which is a central longitudinal section, it will be seen that the cock F, which is acted on by an ordinary swivel, H, and mainspring G, when released by the trigger I, delivers a blow upon the striker K, which passes through the center of the breech block D, directly in line with the axis of the barrel A. The striker K is secured and supported in its chamber by a nut, X. The extractor N is fitted to slide in a groove at the top of the lock plate, and is acted on by a lever, M, which acquires motion from the cock F in such a manner that the old case is slowly but powerfully drawn from the chamber, and afterwards rapidly ejected from the rifle by the striking of the lower horizontal horn F of the hammer against the corresponding projection M of the extractor lever. The stock B is in one piece. The tumbler P is not shown on the sketch. It lies on the right side of the gun, and is fixed upon the shaft R of the lever (not shown). It projects forward and serves to lift and pull down the connecting rod O, animating the breech block.

The arm can be most rapidly operated by omitting the closing action of the lever, and depending for the closing and locking of the breech block upon the connection between the hammer and breech block. To do this, the trigger is pulled when the breech is open. The breech block then falls into place, and is followed by the hammer. Operated in this manner it is said that the arm has been fired sixty times in one minute.

SWEDISH ORDNANCE MANUFACTURES.

The use of birch wood in the Swedish ordnance department for making gun stocks has been abandoned on account of the tendency of this wood to warp in store, and thus to bend the gun barrel. The Swedes are giving up the Bessemer steel on account of its softness, and are now using cast-steel barrels from Austria.

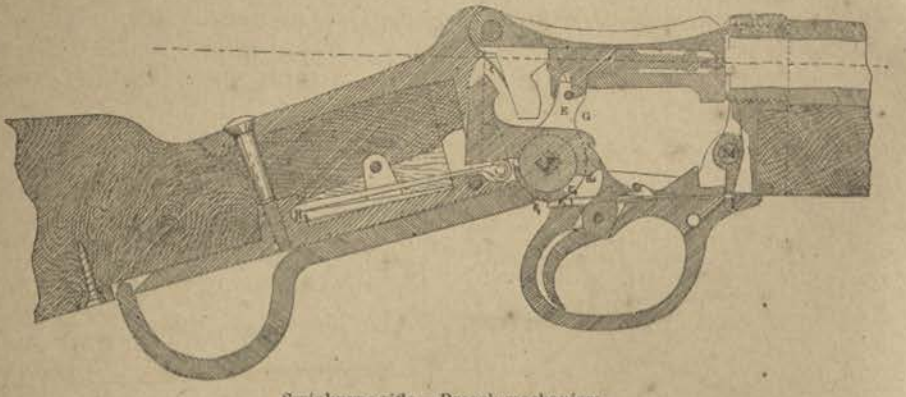
Sweden makes quite an extensive display of the manufacture of the Royal S. A. Factory at Husqvarna, particularly in Remington arms, both for military and sporting purposes. One of the latter—single barrel—is quoted at 38 kroner (about $9.50 gold). A Remington system in the milled stage, 5 kroner. The other Royal S. A. Factory, at Gustafstad, shows a fine collection of progressive stages of the manufacture of Remington arms. As shown, there are 19 operations for the hammer, 31 for the receiver, and 17 for the bayonet.

The Fagersta Bruk Manufactory, Charles Aspelin, agent, New York Hotel, New York, makes a good show of gun barrels tested by the Swedish Government. The molds are 12 inches long, $2\frac{1}{8}$ inch diameter with a $\frac{7}{8}$-inch hole. They were tested with from 336 grains powder and 1 ball of 478 grains, to 672 grains powder and 1 ball. The ordinary proof is 323 grains powder and 1 ball. No effect was produced until 1 ball and 647 grains powder were fired. The gas generally escaped through the vent, the size of which is not stated, swelling the barrel with large charges. Barrel No. 2635 burst in proof with 1,150 grains, the charges being probably gradually increased to that point.

Eskilstima Cutlery Works show a cavalry saber quite heavy, $1.57 gold. Officers' sword blade, 61 cents; steel scabbard about like staff and foot officers' but curved, $2.27 gold; blade for same, $1.21. Handsome Damascus blade, plain, $6.67.

Motala Iron Works, Sweden, Siemens-Martin Furnace, show breech piece, French model, for 11-inch breech-loading S. C. Rifle, also hoops with trunnion piece made of steel coils for 4-inch gun, steel rings $44\frac{3}{4}$ diameter, and 3 inches thick, and $7\frac{3}{4}$ inches wide.

SWINBURNE RIFLE.



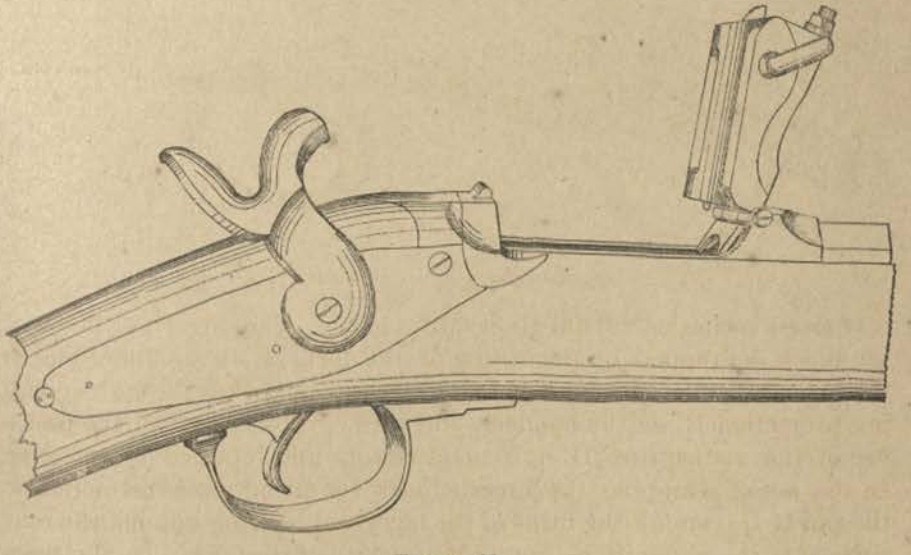
Swinburne rifle.—Breech mechanism.

Opened, as in the Martini-Henry, by a lever. In depressing the lever the block is dropped by the action of the forks E at the upper end of the lever. By the same motion the projection E_4 strikes the corresponding projection H_4 on the hammer, and throws it back against the pressure of the mainspring H_2 until it is caught and retained by the sear. In the act of dropping the breech block the firing pin is retracted by the pin G traversing the forks of the lever and bearing against the rear surface of the notch in the lug underneath the firing pin. By the same pin G the firing pin is kept almost touching the firing point of the cartridge when the piece is closed, thereby diminishing the travel of the firing pin and transmitting the blow of the hammer directly to the primer. At the end of the operation of opening the piece, the shoulder E_5 on the lever strikes the end K_2 of the extractor slide, and shoves this

bodily forward against the lower end of the extractor, causing the latter to revolve around the pin M. This starts the cartridge from its seat in the chamber, with a total leverage of 9:1. The further descent of the breech block strikes the beveled surface K_4, and accelerates the motion of the extractor positively. The joint of the lever around the axis F is made upon the body of the under strap itself, a knuckle joint being formed there to receive it. It has thus no bearing upon the axis pin, which is consequently free from any of the strains due to resistance in closing, either from defects in the construction of the mechanism, or of the ammunition, or from fouling or wear of the parts.

The spring X allows sufficient latitude to the position of the breech block to render the operation of loading an easy one, and to make it independent of the position of the parts supporting the block. The axis of the hammer is provided with an indicator like that of the Martini, but furnished at its upper end with a thumb piece, by which the hammer may be worked independently of the lever. Owing to the absence of the tumbler rest of the Martini, the trigger is set further back, and the "reach" is less than in the other arm. The aim governing the construction of this arm has been to make the devices for firing the cartridge, sustaining the shock of the discharge, and extracting the empty shell, mechanically independent of one another.

THE TERSSEN BREECH-LOADING RIFLE (BELGIAN).

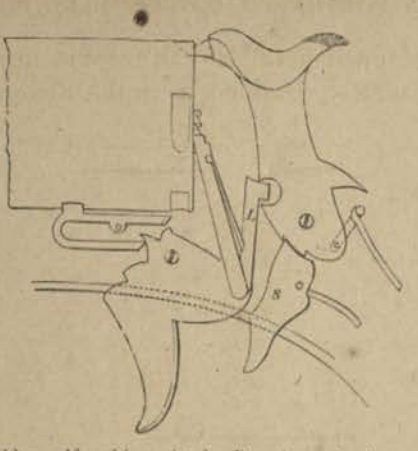


Terssen rifle.

By turning the key upward and forward, a bolt, traversing the breech block longitudinally and entering a recess in the breech pin, is withdrawn from the breech pin and allows the block to be opened. A hole made in the head of this key allows a rod to be used if extra force is required.

An extractor on the axis of the breech block overlies the upper half of the mouth of the chamber. No means of accelerating its motion are provided.

WEBLEY SELF-COCKING PISTOL.



Webley self-cocking pistol.—Breech mechanism.

The sketch shows the working parts. By the act of pulling the trigger the lift L is raised, carrying with it the front portion of the hammer and causing the hammer to revolve backward in the ordinary way. By continuing the motion of the trigger the lift is carried out of the circular notch in the front side of the hammer, which allows it to fall. The hammer may also be worked by hand in the usual way, in which case by pulling the trigger its rear surface strikes the sear S and throws out its upper end from the notch in the tumbler portion of the hammer.

In the act of pulling the trigger, the foremost horn at its upper end presses down the rear end of the stop, raising its forward end into the proper notch of the cylinder and holding the latter stationary during the firing. The return of the trigger forward, under the influence of the spring in which the lower portion of the stop is formed, raises the rear end of the stop by the upper horn. This releases the forward end and allows the cylinder to revolve freely.

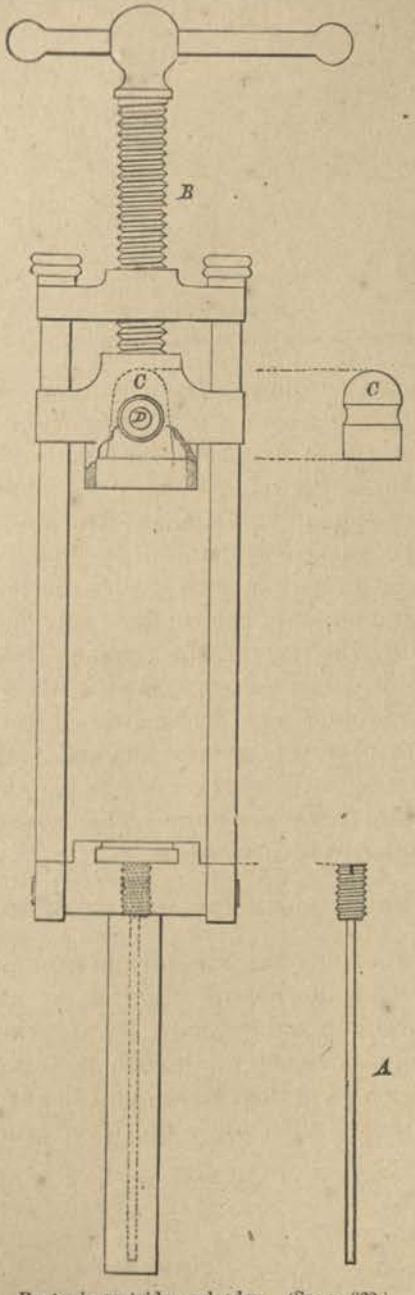
VETTERLIN MAGAZINE RIFLE IMPROVED.

A new model of this gun has the upright arm of the carrier lever separate and projecting downward through the stock, near which it terminates in the form of a screw head. By lowering this arm until its upper end is free from its slot in the breech bolt, the withdrawal of the breech bolt no longer affects the carrier, and the arm can consequently only be used as a single loader until the lever arm is replaced in contact with the breech bolt.

CLASS D.—SMALL-ARM AMMUNITION.

AMMUNITION FOR BARON HAHN'S WALL PIECE (RUSSIAN).

The case is of wrapped metal, .80 caliber at mouth, and 3.75 inches long. The metal is not spirally wrapped, as in the Boxer cartridge, but a lon-



Burton's cartridge reloader. (See p. 862.)

gitudinal seam is formed locked like a tinner's seam. The bottom of the case is turned over so as to leave a hole large enough to admit the anvil recess in the outside cup. The metal of the case itself is quite thin, about No. 24 wire gauge, but inside and outside cups are much heavier, about No. 16 wire gauge. The center of the outside cup is formed into a Berdan anvil. The inside cup (gas check ?) lies flat against the bottom of the case. All three thicknesses are slightly pressed in under the head to bind them closely together. The bullet is of smooth steel covered with lead.

See description of wall piece.

BURTON CARTRIDGE RELOADER.

The needle A serves to extract the empty cap by passing it down through the body of the shell and then bringing upon it the pressure of the screw B. The new cap being set in place by hand is pressed into its seat by the flat end of the detachable piece C, which is held in place by the set screw D. The cartridge shell having been filled is slipped into the recess, where it is held during the insertion of the ball. The latter is pressed home, in the same manner as the cap, the rounded part of the recess for C fitting over the ball. No reducing die is provided. It is supposed that this reloader is intended for use with the Lowell shell.

B. Burton, 54 Wall street, New York.

PERCUSSION CAPS.

Eley Bros. exhibit their well-known varieties of percussion caps, wads, and paper sporting ammunition. Almost all their bullets are patched. Those which are cannelured contain about 6 grooves about .04 wide. They appear to be lubricated with bees-wax or other dark material, which is not cleaned off between the grooves. They exhibit both wrapped metal and solid case cartridges of about .45 caliber and of an extreme length of about 4 inches.

SMALL-ARM AMMUNITION (FRENCH).

Maison Givelot, Paris. Shows various kinds of cartridges.

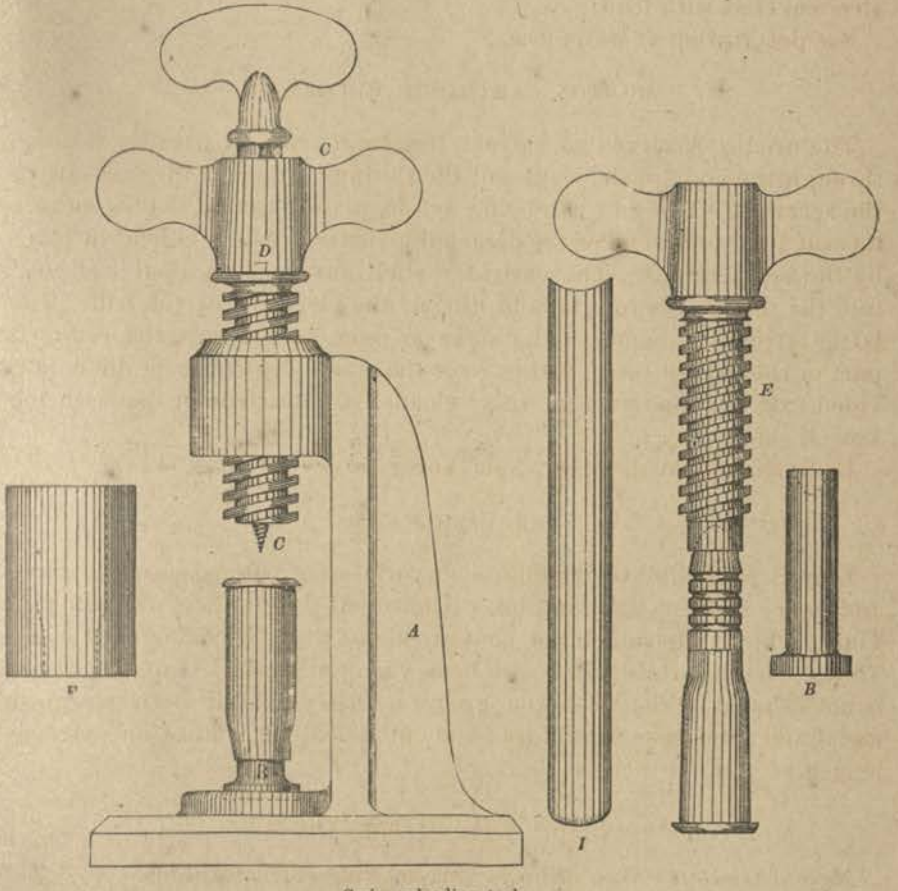
Mitrailleuse cartridge (*Frey*). It is of wrapped metal with a *culot* of homogeneous paper or clay in base; wad between powder and ball; lap of case over ball, $1\frac{3}{8}$.

Pertuiset's explosive bullets, containing the explosive substance in a thimble inserted into the bullet from the front. The thimble appears to be inserted into the bullet while the fulminate is wet. It is then pressed in, being held by corrugations in the cavity of the bullet. Probably then dried through holes in the top, which are afterwards covered with varnish.

French gras cartridge.—The French "gras" cartridge made from brass in eight draws; solid head.

Givelot runs his blank strips wider than is usual with us, *e. g.*, 5 oblique widths of about 1.25-inch disk, making strip about 12 inches wide; also brass, about 6 inches wide and $\frac{3}{16}$ thick, with 6 oblique holes; shows also Gatling cartridge 1.00 inches caliber, solid square head, re-enforced with solder. Cartridges for a wall piece of about .70 caliber are shown; bottle neck; Berdan system; about 4 inches long.

SWISS RELOADING TOOLS.



Swiss reloading tools.

The spent cap is extracted by means of the gimlet-pointed screw C, traveling axially through the coarse screw D, the latter serving to steady the cartridge on the mandrel B. F is the reducing die, from which the cartridge is knocked out by the pin I. E is the loading screw, being substituted for D, in the frame A, when necessary.

CLASS E.—EQUIPMENTS, LEATHER WORK, &c.

BRAZILIAN INFANTRY EQUIPMENTS.

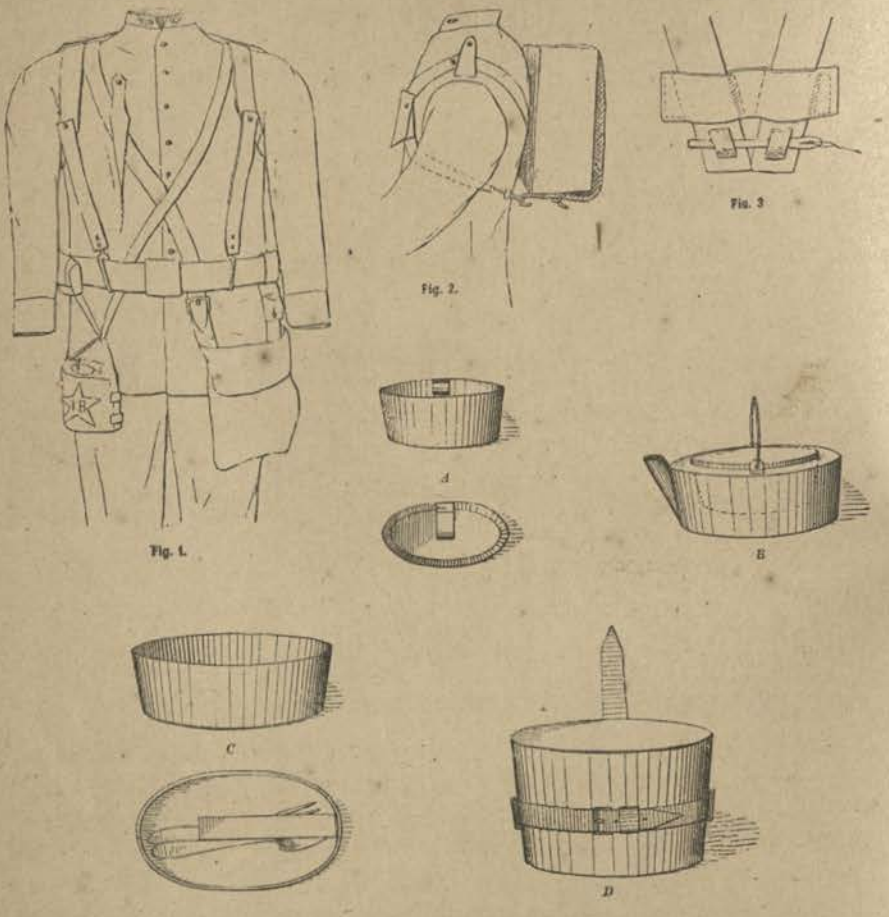
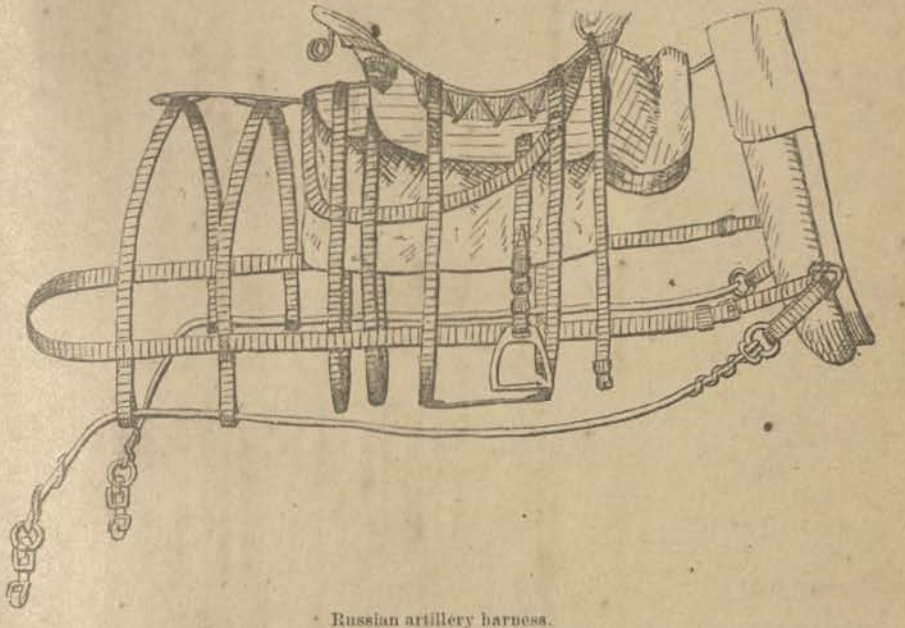


Fig. 1 represents a front view, showing the shoulder braces, waist belt, tin canteen, and linen haversack. A pick wire is fastened to the right breast of the coat. One end of the knapsack straps is secured to the inner side of the knapsack by the loop and pin shown, Fig. 3. The other end passes over the shoulder to the hook on the under side of the knapsack, as in Fig. 2. The square cartridge box of the ordinary form is worn at one side upon the belt. The mess can is carried upon the knapsack. The drinking cup A, with a jointed handle, fits into the tea-pot B. This fits in the bottom of the can D. The fork and spoon are carried in the lid of the pan C. The lid has a jointed handle to use in cooking. The pan fills the upper portion of the main can D, over B, its lid when inverted serving for both pieces.

THE RUSSIAN ARTILLERY HARNESS.

The collar is of the Roubitz type, elsewhere described. To the eye in the iron hames is fastened a stout leather tug strap, connected by means of an iron ring with the rope traces. These are of single length spliced into a ring at each end. The traces are sustained by two loop straps hanging from the breech strap just below the point of attachment of the hip straps. The breech strap is terminated at its forward



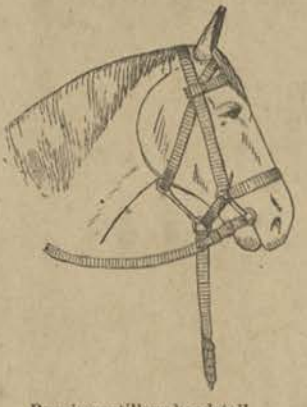
Russian artillery harness.

end by a triangular ring hooking over the eye of the hame and kept from coming off by the tug. (It is so exhibited, but presents so clumsy an appearance that some other disposition of it in practice is by no means improbable.)

The breech strap is supported by three hip straps, the forward one of which passes under the belly. There is no crupper, the rear hip straps on each side joining the back strap in a pad. The girth is formed of two 1½-inch straps crossing the saddle near the foot of the arcs, and secured to the bars by thong lacings. A short longitudinal belly strap keeps them from slipping. The saddle is of wood with high peaked pommel and cantle. The stirrup straps pass through holes mortised in the bars.

Suspended between the pommel and cantel is a 2-inch seat band of tough white leather, laced to the side bars by thongs, and split to form an eye at each end passing over the pommel and cantel, where it is lashed with thongs. The projection of these straps, thongs, &c., renders the seat so uneven that is customary to provide a cushion for the rider. The cushion itself is not shown, but its retaining straps form part of the

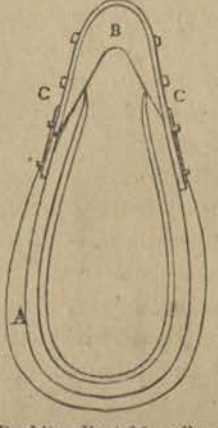
harness. They consist of a 1¼ inch strap girdling the horse back of the saddle, through loops formed in the upper part of which passes a continuous narrow strap secured to the pommel. A second retaining strap, ¾ inch wide, passes over the cushion and around the horse immediately in rear of the pommel. A fourfold thick felt blanket is protected by a leather cover, on the rear corners of which are stitched side pockets for horseshoes, &c. A pair of leather pouches is slung in front, the connecting strap resting on the pommel. The horse is guided by a bridoom bit with a toggle fastening.



Russian artillery headstall.

The headstall forms part of the halter, the throat strap passing through the loop of the brow band, and the tie strap being united with the cheek rings by means of a strap passing through a ring to which the short under jaw strap and the tie strap are also fastened. The stirrup is of iron, open; of the English pattern. The lead harness is the same throughout including the breeching. The lead traces are united to those in rear by a double hook, the points being turned to meet each other, and each provided with a square ring pawl to prevent accidental detaching.

COLONEL ROUBITZ'S ADJUSTABLE COLLAR (RUSSIAN).

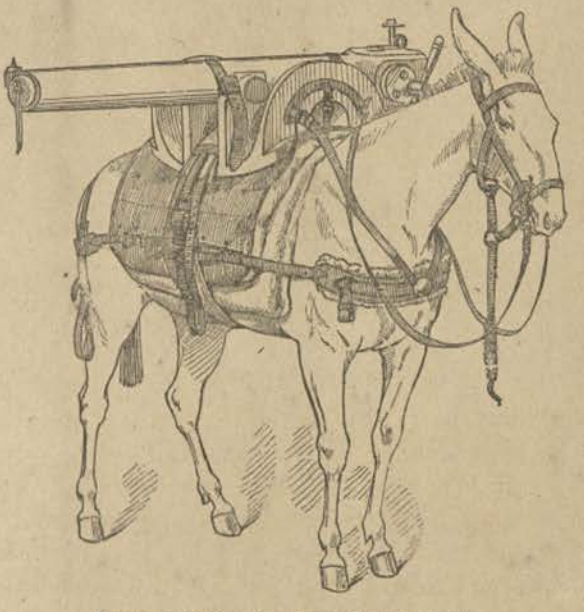


Roubitz adjustable collar.

The collar is composed of three pieces, the body of the collar, A, the saddle piece, B, and iron strap, C. The strap is pierced with holes to receive loops attached to the two parts of the collar; pins passing through these loops keep the collar at any required distension.

No provision appears to have been made for a proportionate change in the bearing surfaces of the collar with a view to the proper distribution of the weight after making the adjustments necessary in changing from a large to a small horse, and *vice versa*.

KRUPP MOUNTAIN HOWITZER, PACKED.



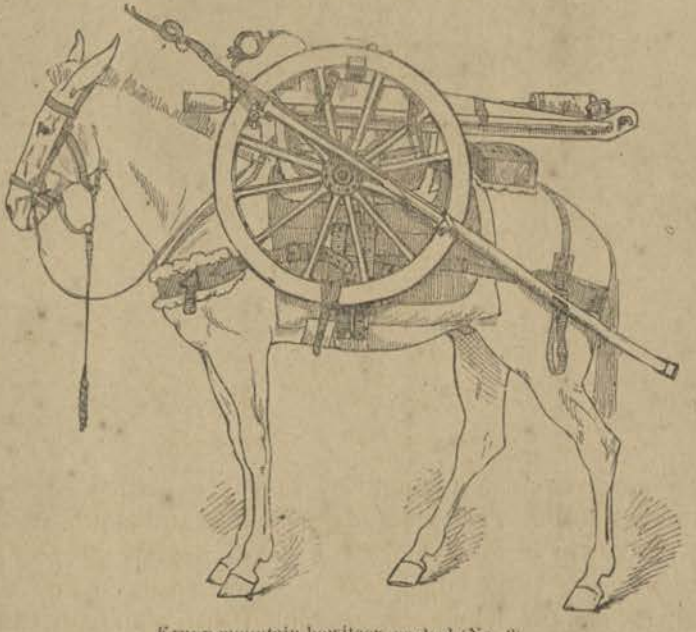
Krupp mountain howitzer, packed (No. 1).

The gun is provided with a solid breech-block moving in a square mortise through the breech. Horse No. 1 carries the gun on a special saddle, upon which the gun lies across the animal. The saddle consists of a side bar of the ordinary form with high semi-circular pommel and cantle. Between them are two cross transoms stiffened by iron straps. These transoms are united by one short longitudinal transom over the left side bars. The cross transoms receive the trunnions of the gun at a point about 3 inches to the right of the center. The longitudinal transom is hollowed out for the breech.

The gun is fastened down by leather straps passing over it from one transom to the other. The saddle is secured to the animal by a 6-inch webbing girth filling the space between the cross-transoms, probably to give some elasticity to the attachment, although it is securely screwed to each of the side bars, yet the girth passes over two strips of 3-inch webbing stretched between the pommel and cantle and passing under the cross-transoms.

The pad is made in two pieces about 1.25 inches thick, separated along the backbone, stuffed with wool, and quilted to a leather cover. Under the pad lies a blanket folded in four thicknesses.

From the front side of the pommel a pair of straps run diagonally to the animal's chest, where they unite in a breast strap with a sheep-skin lining. Each end of this breast strap is buckled into a strap sewed to the leather pad cover, the rear end of this strap buckling into the breech strap. Attached to the ends of separate straps sewed over the breast-strap are short tugs which buckle into eyes on the end of the shafts. A strap hangs from the upper part of the girth, where it is attached to the saddle, and passes through a D staple on the shaft. The shaft is further supported in rear by a strap hanging from the junction of the hip and breast strap. The hip straps start from opposite sides of the back of the cantle and cross over the rump.



Krupp mountain howitzer, packed (No. 2).

Horse No. 2 carries the carriage complete; the stock is carried longitudinally on top of a rather long pack-saddle, the pommel and cantle being flattened to receive it. Small knee-shaped pieces are bolted on the under side of the stock, and keep it from moving longitudinally. It is kept down by heavy straps passing from irons, let into the side bars, and passing over the stock. The wheels are carried on the side, hung from a notched wooden cross bar resting on the stock and held by turning down the head of the elevating screw upon it. The axle, which is not removed from the stock, passes through the spokes of the wheels. The straps which secure the stock to the saddle are twisted around the spokes of the wheels, and hold them in place. They are further secured

by a surcingle joining their lowest points. The shafts rests upon the front of the stock and point diagonally downward to the rear. They are strapped to one of the spokes of the wheel, on each side.

The shafts have prolongations of iron notched in opposite sides, which in traction pass respectively under a hook in the side of the trail near the end, and over an eye further up the stock. The notch engaging with the hook is secured to it by a swinging bar and pin. Beneath the trail is placed a heavy pad to protect the animal's rump from bumping, &c. It is secured by the diagonal hip straps. The harness otherwise is as in No. 1.

Krupp mountain howitzer, packed (No. 3).

Horse No. 3 carries the ammunition in boxes suspended by chains from a special saddle. The halves of the pommel and cantle are notched into each other, sawbuck fashion. The boxes are steadied by a girth joining their inner lower edges. They are of wood, bound with iron, with single covers, the joint being protected with a strip of canvass.

OIL BOX (RUSSIAN).

This is a brass box 2.75 by 0.75 by 1.5 inches, divided into two compartments by a partition. One compartment for oil is closed by a screw-plug, the lower end of which has a notched wire stem which serves as a dripper. The other compartment, provided with a hinged lid, is intended for a small piece of chamois skin. A brass loop serves to fasten it to the equipment.

RUSSIAN MOUNTAIN HOWITZER, PACKED.

One piece only is exhibited a short 3-inch breech-loading bronze rifle, with bronze Krupp breech-block, its carriage, ammunition, &c., packed

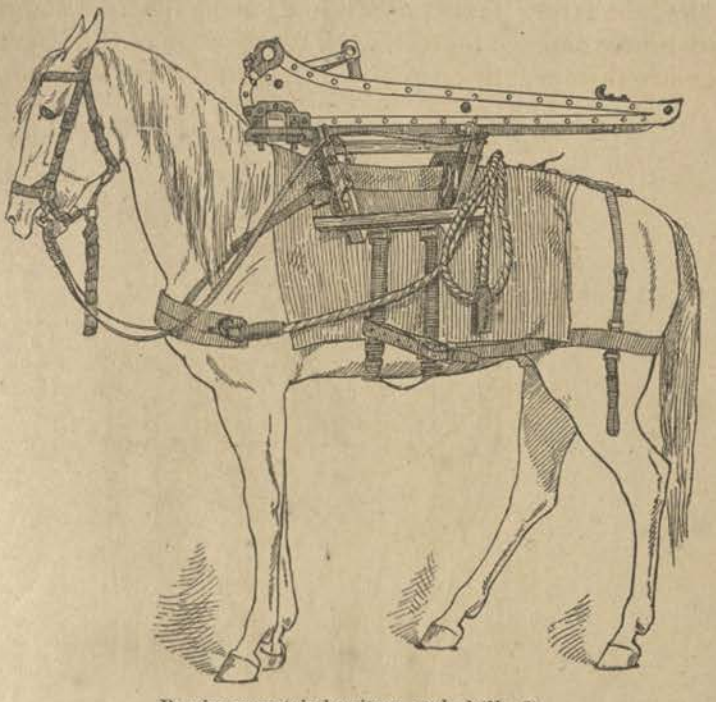
on four horses; three of these are simple pack-animals; the fourth, which supports the carriage, is arranged for draught.

No. 1 horse carries the piece, which is placed lengthwise on his back, muzzle to the rear. The breech and muzzle are supported on properly shaped transoms front and rear. The trunnions rest on side bars joining the two transoms. The bars of the saddle are curved very much as in the McClellan tree. Over the bars and joining the front and rear transoms are braces notched to receive the trunnions. To the front transom, D rings are fastened, by means of which the breast strap is secured.

Russian mountain howitzer, packed (No. 1).

The rear straps from the sides of the cantle are unite in a ring secured to a rump pad underlying the hip strap which supports the breeching. The saddle is double-girthed with heavy leather straps 2 inches wide, kept together by a broad double loop under the belly, to which the martingale is attached. Under the belly and between the two girths passes a single strap which about half way up on each side forks into two parts which are alternately provided with a buckle and tongue holes. These are strapped over the gun on each side of the trunnions, and serve to keep it in its saddle, the breeching buckles around both girths passing, however, over the pack strap. The breast straps unite in a breast pad, from which the martingale passes to the belly loop before described. The saddle rests on three thicknesses of double felt, in all about 1.5 inch thick, which cover about the upper half of the

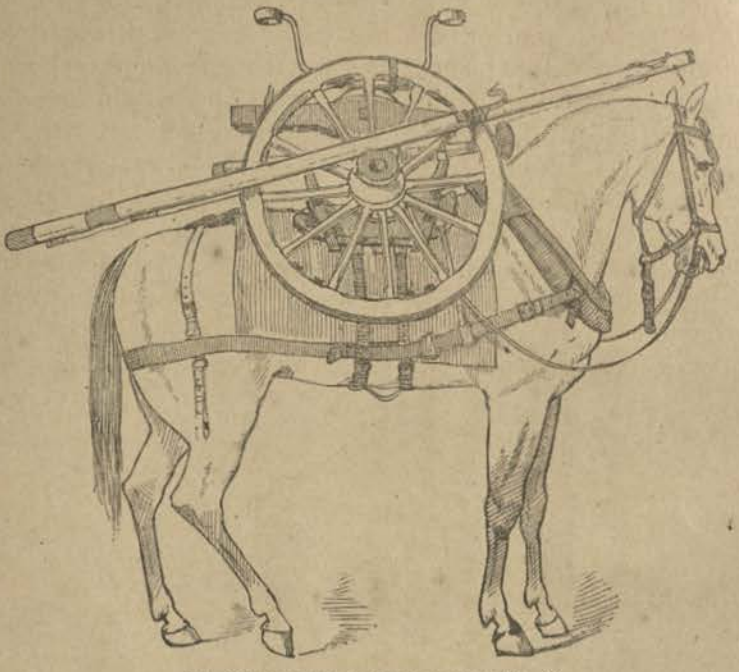
horse's body, and reach from his withers to the stifle. This blanket is covered with a piece of well-oiled bag or grain leather, about 4 by 2.5 feet, which serves to protect it from rain. The halter is of the usual form, provided with a watering bit, the reins of which are long enough to unite behind the saddle. The toggle of the watering bit is somewhat peculiar.



Russian mountain howitzer, packed (No. 2).

The body of the gun-carriage is supported on horse No. 2 on a special saddle, upon which it rests longitudinally, the trail pointing to the rear. The front and rear transoms are notched on the sides so as to fit in between the side pieces of the trail, and prevent lateral motion. The carriage is kept down upon the saddle by two half-inch iron rods which, hinge fashion, pass through four iron loops riveted to the under side of the stock, and through two iron loops secured to the inner faces of the front and rear transoms of the saddle in line with the loops on the stock. A head formed at one end of these rods keeps them from going through in one direction, while a short section just beyond the loop at the other end, jointed like a parasol handle, keeps it from inadvertently slipping back. This horse is provided with a breast strap, to which rope traces of double length are fastened. When not in use, these are folded across his rump. This horse is probably intended to be used as a leader when the carriage is in traction. The other portions of the harness are as in No. 1. The carriage is of heavy sheet-iron or steel stiffened by an angle iron riveted to the edges in such a manner that the flanges formed on

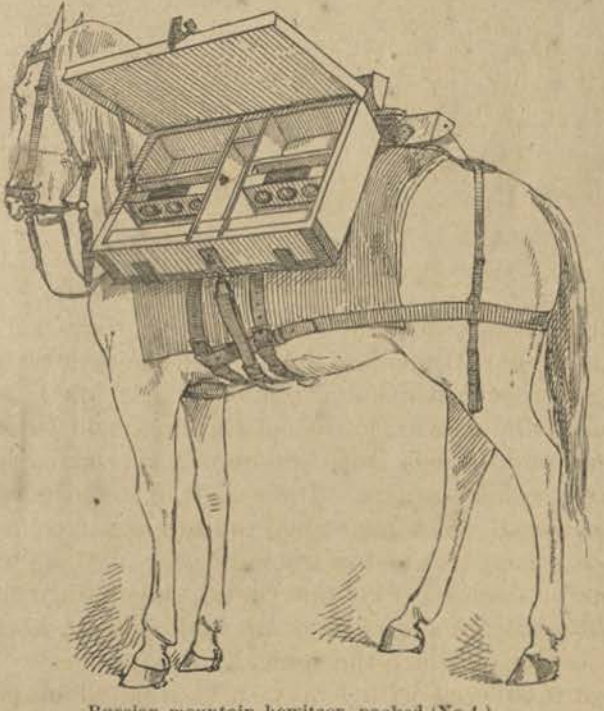
the flasks will lie toward each other. The sides are braced by (1) a through bolt beneath the trunnion; (2) the elevating-screw box, the bearings of which are secured by two of the flange rivets; (3) by a through bolt at about mid length of the trail; (4) by a through bolt in rear; (5) by a cross lunette strap bolted to the upper side of the flanges near the trail end. This strap is perforated in the middle for the pintle, and has two ears curled in front of it up over the top flanges; (6) by a similar strap, but with a larger hole joining the flasks from beneath.



Russian mountain howitzer, packed (No. 3).

Horse No. 3 is apparently the wheel horse of the team, as he is furnished with a collar (Colonel Roubitz, which see) and traces. He carries the axle, wheels, shafts, and pintle. The saddle is especially designed to carry the axle. The top of the front and side transoms is quite narrow, and the side irons run up to form square notches to receive the axle, which is square. The weight of the axle and that of the rest of the material which rests upon the axle is sufficient to keep it in place, as it is merely steadied in front and rear by thongs fastening the arms to loops on the leather blanket cover. Upon the axle rests on edge the pintle bearer. This consists of an arm of wood, about 3 feet long, through the center of which the conical pintle projects. Its upper and lower sides are covered with heavy sheet iron, which is raised at the end and curved so as to form loop sockets for the shafts. A pin passing through these sockets, and corresponding holes in the butt of the shafts, serves to keep the latter in place. A curved round iron arm passes through this wooden arm in the same plane with it and terminates in

eyes through which the body of the shaft passes when in traction. This gives it a long bearing and diminishes the strain on the pins. This curved arm is braced by a straight brace near the wooden body. The pintle passes through the lunette plates in the trail from *below*, and is confined by a key of the usual form which rides upon the upper lunette plate. To the under side of the arm are bolted two trace hooks, points of attachment for the long rope traces of the lead horse. The wheels lie flat on each side of the saddle, sockets being cut to receive their hubs in the heavy side pieces which fill up the space between the transoms, and above the side bars. They are strapped together where they meet on top. The shafts lie outside the wheels pointing fore and aft; they are straight cylinders of wood about 2.5 inches diameter, covered with sheet iron where they bear in the sockets. At about one-fourth the length from the forward end is a twisted hook through which the traction is applied; a short trace connects it with the hames. The weight of this trace is supported by a light strap running up to the saddle. At the forward end of the pole a pin traverses it vertically, probably for attaching a third horse with double length traces when necessary in traction. The forward axle arm is kept from chafing the horse's neck by a grommet pad. The pad, breeching, &c., is as in No. 1.

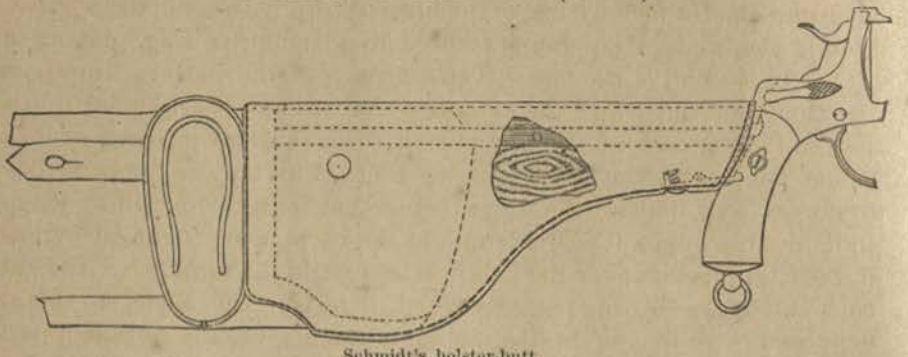


Russian mountain howitzer, packed (No 4.)

Horse No. 4 has a special saddle resembling in its general form that of No. 2; on each side at the pommel and cantle are fastened stout iron hooks, from which depend the ammunition boxes, one on each side.

They are 27 by 16 by 6 inches, made of wood covered with sheet iron. They are kept tight by means of a girth passing under the horse's body and fastened to a △ ring at their lower edge. The other arrangements of the harness, &c., are as in No. 1. The boxes have a hinged cover to protect the hinge joint from rain, and are provided with bail handles at each end. They are divided into compartments inside, which hold seven shot standing on end upon the lower side of the box. The saddles on horses No. 1 and 2 are provided with side hooks on which boxes may be slung if necessary.

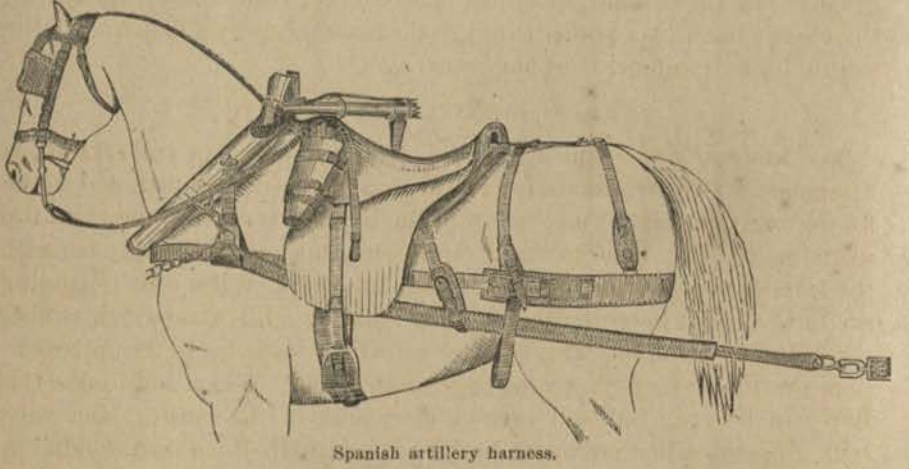
SCHMIDT HOLSTER-BUTT (SWISS).



Schmidt's holster-butt.

Within the holster is an iron frame from the pipe end of which project the hook and spring catch necessary to convert the holster into an adjustable butt-stock. The pipe end is made of wood hollowed to fit the pistol-barrel. The lid is made extra heavy for a similar purpose. The holster is carried by a shoulder sling.

SPANISH ARTILLERY HARNESS.



Spanish artillery harness.

With the exception of the absence of the pole yoke and in a few minor details, this resembles closely for the individual harness that adopted by the United States. The collar is apparently made on a wooden frame which is covered with leather, stuffed, and permanently secured to the

iron hames. The collar opens below; above it carries a folded housing as a protection against rain. The eye is made in the shape of a hinged hook, the mouth of which may be closed by a guard strap. From this hook hangs the trace chain of three loops, to an eye formed in the lower one of which is fastened the lead trace chain. The traces are of rope covered with leather, the covering being re-enforced by an additional sleeve over the part most subject to wear. They are attached to the splint bar directly by means of hooks such as above described. The breech strap is very wide and heavy. It is sustained by two hip straps from the back strap. A loop for the trace hangs from the saddle, and also one from the forward end of the breech strap. The pole strap passes around the breast strap and is secured to a triangular ring, playing in an eye in the end of the pole. The saddle is of the pattern known as the English saddle, with the exception that for the wheel horses it carries on the pommel a fixed jointed ring, through which passes a wooden jockey bar joining the two horses together. This bar is allowed to play freely between limits in the rings, being kept from coming off by longitudinal straps upon it. Mid-length of the bar a heavy strap surrounds it and also passes under the pole. It is kept in the middle by studs at each end of the bearing plate on which it rests. The object of this is supposed to be to equalize the motion of the horses, and to take a part of the weight of the pole when not fully counterbalanced by the limber chest in rear. Each horse carries on the outer saddle bow a leather forage bag. The lead harness resembles that of the wheel horses except in the breeching. The traces are sustained by a special hip strap besides the one on the saddle.

SPANISH CAVALRY SADDLE.

This is of the ordinary English type. The valise in rear is kept off the horse's back by a pad, secured to the back strap by a loop and to the saddle by two independent stay straps.

SPANISH INFANTRY EQUIPMENT.

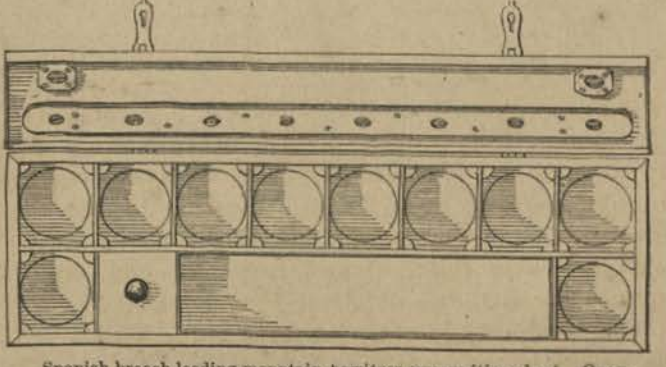
The knapsack of enameled cloth, stretched upon an iron frame, is attached by two straps passing under the shoulders, and fastened to the knapsack frame, above and below. The blanket is carried rolled on top in the usual way. The haversack of linen is suspended directly beneath the knapsack in a similar way. Shoulder straps on the coat buttoning up to the collar keep the straps from slipping off. A separate rubber cloth flap is provided, which is pierced with two holes in its upper corners for the haversack straps to pass through. When not in use this flap can be removed and carried elsewhere in the outfit. The waist belt supports a leather water bottle covered with linen on the left. A stiff flat leather ammunition pouch on the right is suspended by a cross belt from the left shoulder. The reserve ammunition is carried in a square cartridge box with two tin compartments in rear, upon the waist belt. The bayonet scabbard is of leather of the old triangular pattern.

Spanish infantry equipment.

This outfit for sharpshooters is the only one shown. I am informed that it does not differ materially from that worn by the line.

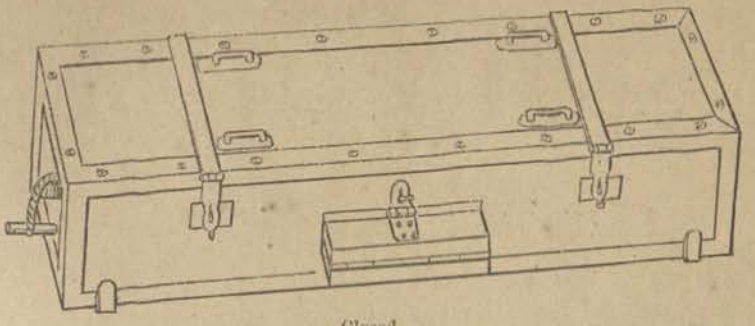
AMMUNITION CHEST FOR SPANISH BREECH-LOADING RIFLED MOUNTAIN HOWITZER.

This is made of pine except on the side next to the animal. It contains spaces for 10 shell separated by inch partitions. Also an open



Spanish breech-loading mountain howitzer ammunition-chest. -Open.

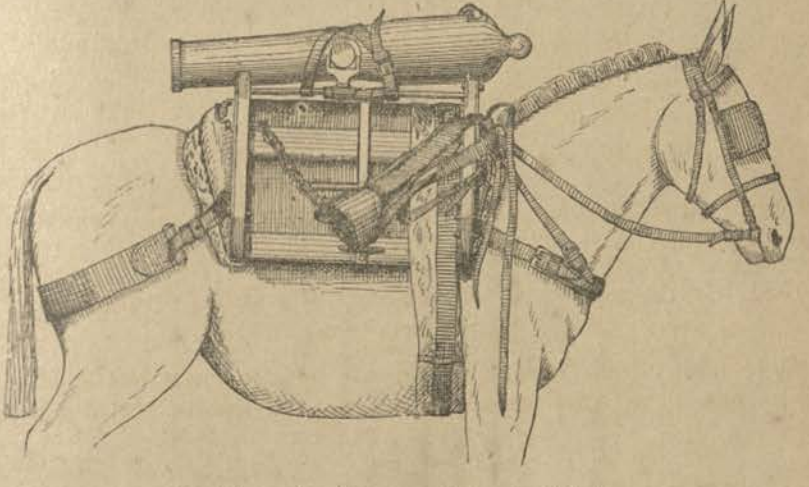
zinc powder box, and another box with a lid. The primers are carried in a small box outside. The points of the shell rest against rubber bumpers on the lid.



Closed.

SPANISH MUZZLE-LOADING MOUNTAIN HOWITZER, PACKED.

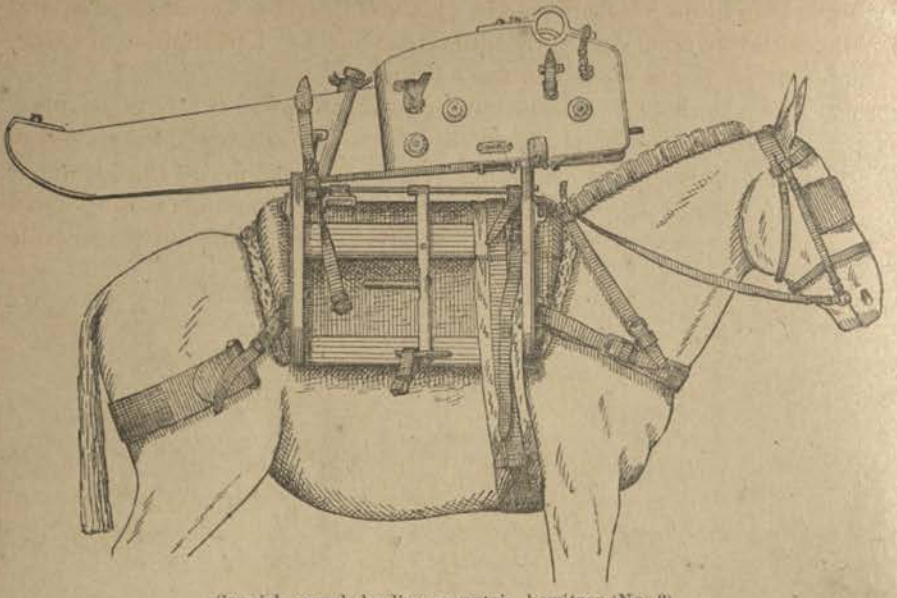
The saddles are all alike. The front and rear arcs are connected together by heavy iron rods, upon which slide U-shaped trunnion-rests. They are also connected by the bars of the saddle, and by a broad iron strap joining their lower ends. Their outside faces are covered with



Spanish muzzle-loading mountain howitzer (No. 1).

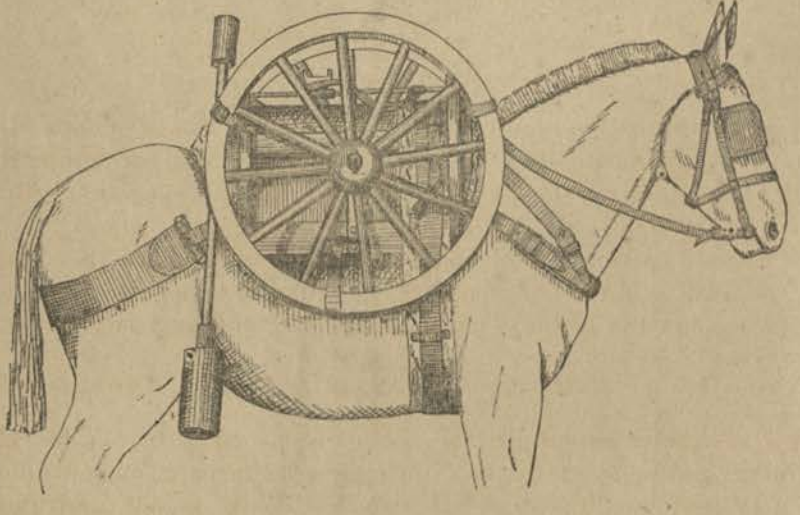
plate iron to their entire extent. These rods are also connected by two wide leather straps. The saddle rests upon an especially thick, quilted woolen pad upon which it is firmly girthed by a webbing girth and leather surcingle, secured by a cinch and passing around the animal just in rear of the front arc of the saddle. The breast and breech straps lead off from staples in the front and rear arcs of the saddle. The breast strap is supported by a diagonal strap buckled to the pommel. The breech strap is unusually wide. A vertical iron bar about half way between the arcs joins the upper and lower iron rods together, being

ivetted to the wooden bar between. At mid-length is hinged, by a sleeve joint, an arm, upon which the wheel is put when packed. At



Spanish muzzle-loading mountain howitzer (No. 2).

other times it is turned sideways flat with the pack. The front and rear arcs are hollowed out for the breech and muzzle of the piece, which



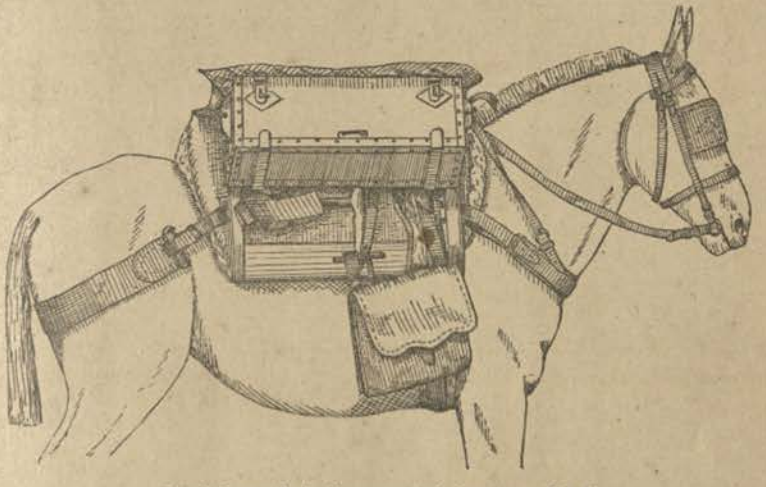
Spanish muzzle-loading mountain howitzer, (No. 3).

is secured by the straps joining the slides of the trunnion-rests, crossing the piece diagonally. The trunnion-rests keep it from turning in its bed.

The stock and axle are carried together fore and aft on another animal, No. 2. A cleat on each side of the front arc keeps the stock from mov-

ing laterally. It is also secured by square notches in the arc and by leather straps passing from pins projecting inwardly from the two arcs, through iron loops on the side of the stock. The wheels, shafts, and rammers, are carried on a third animal as shown. The manner of carrying the shafts is not shown in the exhibition.

The wheel is placed upon the hinged arm turned out for the purpose. It is fastened to each of the arcs by the inside straps used to secure the stock in place. It is also secured to the lower longitudinal iron bar by a strap passing through a loop upon it. The rammers hang head downwards, by rings fastened to the staves, from hooks on the outside of the cantle.



Spanish muzzle-loading mountain howitzer (No. 4).

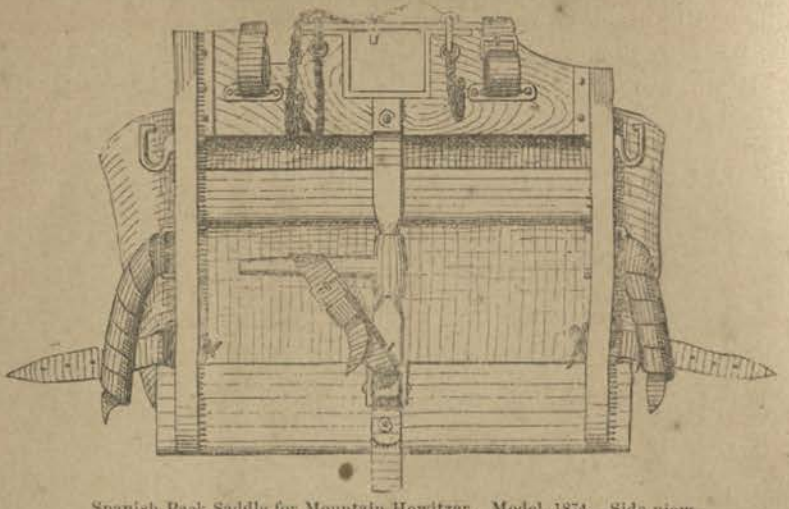
The ammunition boxes are hung by chains from hooks outside of the arcs, near their upper corners. They are steadied there by passing their rope handles through the same hooks. No positive connection with the animal is shown.

Each mule carries a stable halter on the saddle-bow. (See No. 1.) The headstall is of the ordinary pattern, with a tieing-halter attached. The piece shown is a bronze muzzle-loading rifled howitzer.

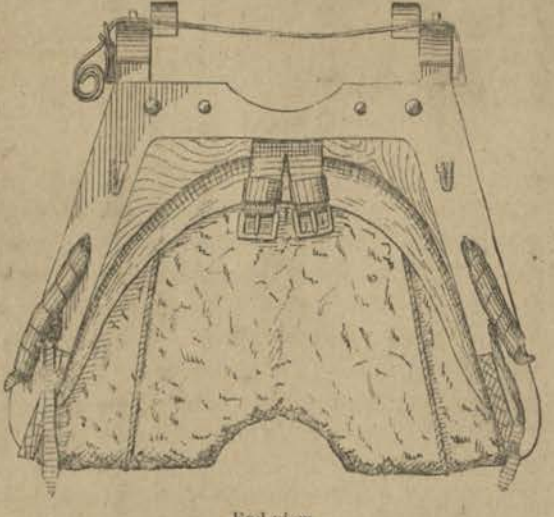
SPANISH PACK SADDLE FOR MOUNTAIN HOWITZER. MODEL, 1874.

This resembles essentially the system described, page 877, but is an improvement upon it in the way of simplicity, efficiency, and cheapness. The arcs are joined by two wide bars on each side, besides the trunnion transoms which are all of wood. The trunnion transoms are notched for the trunnions and the axle. The number of straps is reduced and their attachments simplified. The breeching is supported by limp straps, but none are provided for the breast plate. Both breech strap and breast plate are fastened by leather straps passing through holes in the arcs. The holding-down straps are fastened by foot staples to

the trunnion transoms. The cap squares are provided with semi-cylindrical caps on their interior surfaces, probably for use with special guns whose dimensions and the position of whose center of gravity do not permit the use of the ordinary square notches in the transoms. The



Spanish Pack Saddle for Mountain Howitzer. Model, 1874.—Side view.



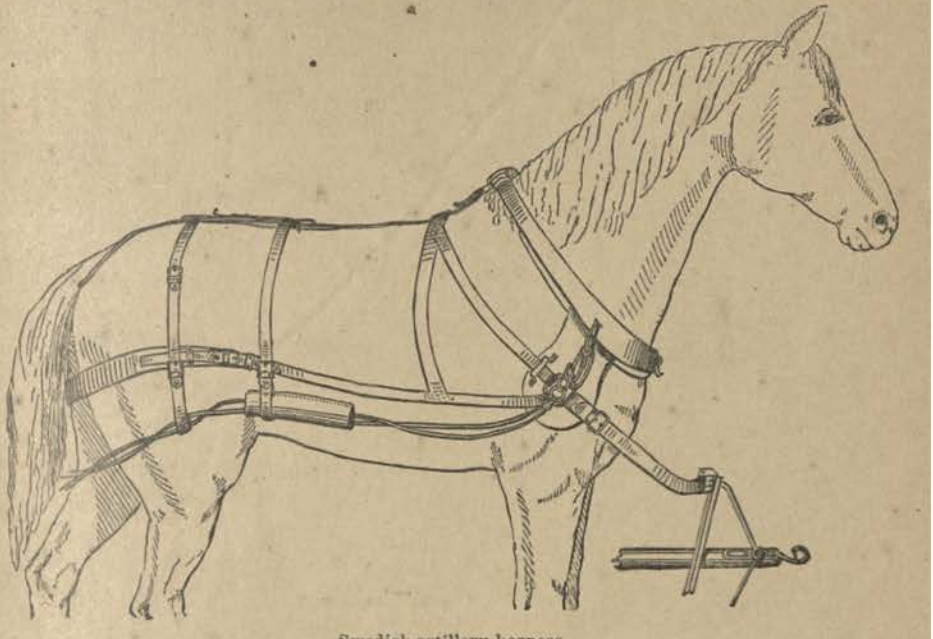
End view.

most striking feature in this saddle is the enormous thickness given to the pad. This is made of felled wool, and is solid 13 inches thick. It necessarily throws the center of gravity of the load quite high. It is covered with leather and retained by diagonal cords in front and rear.

SWEDISH ARTILLERY HARNESS.

The collar is of wood slightly padded. The rope traces are knotted in front to a ring hanging from a link supported by a hook, fastened

to the eye of the hames by another link. The loose end runs back nearly the whole length of the trace. They are of 1.5 rope spliced in rear to an eye secured by a hook to the eye of the single-tree. They are passed through each other's thickness at points, and also surrounded by a leather sleeve to keep from tangling and chafing. This sleeve hangs from the back strap in rear, and is stayed in front by a leather thong



Swedish artillery harness.

running to the traces. From the link next below the eye in the collar hangs by a leather strap a ring into which the pole strap buckles. The pole strap passes through the loop in the end of the pole yoke around to the other side of the collar. From this ring passes up diagonally backward a stay strap fastened to a strap which encircles the body of the horse in front of the saddle place. This strap is intended to take the weight of the pole yoke, and also a part of the strain in backing. The breeching also passes from this ring around the body of the horse. Underneath this assemblage of two rings, two links, one hook, and one thong, is a wide leather flap to prevent shoulder chafing. The hip strap has buckled to it a loop strap to support the trace. The back strap passes around the top of the collar and runs backward under the saddle to the crupper.

The saddle-tree is of wood covered with raw hide and covered with a movable leather cover. The stirrups are of the open iron pattern. A tinned curb-bit, much like the United States model of 1861, and a snaffle-bit are used. The bits have curved branches. The halter goes around the throat, being fastened by a strap to the crown-strap. The tie of the halter is of rope. The lead-horse harness is like that of the

wheel horse except the breeching. In time of war all horses are saddled alike. The chief of piece (Swedish constable) rides a horse with a breast-strap as a relief for horses having sore shoulders.

Swedish single harness.

The blankets of the men are carried on the seats of the limber chest. Their spare shoes and clothing are in bags placed on the chest under and in rear of the back.

The single harness shown is used with the forge cart. It does not differ in principle from that above described.

CLASS F.—MACHINERY.

ALEXANDER BROTHERS.—WIDE LEATHER BELTING.

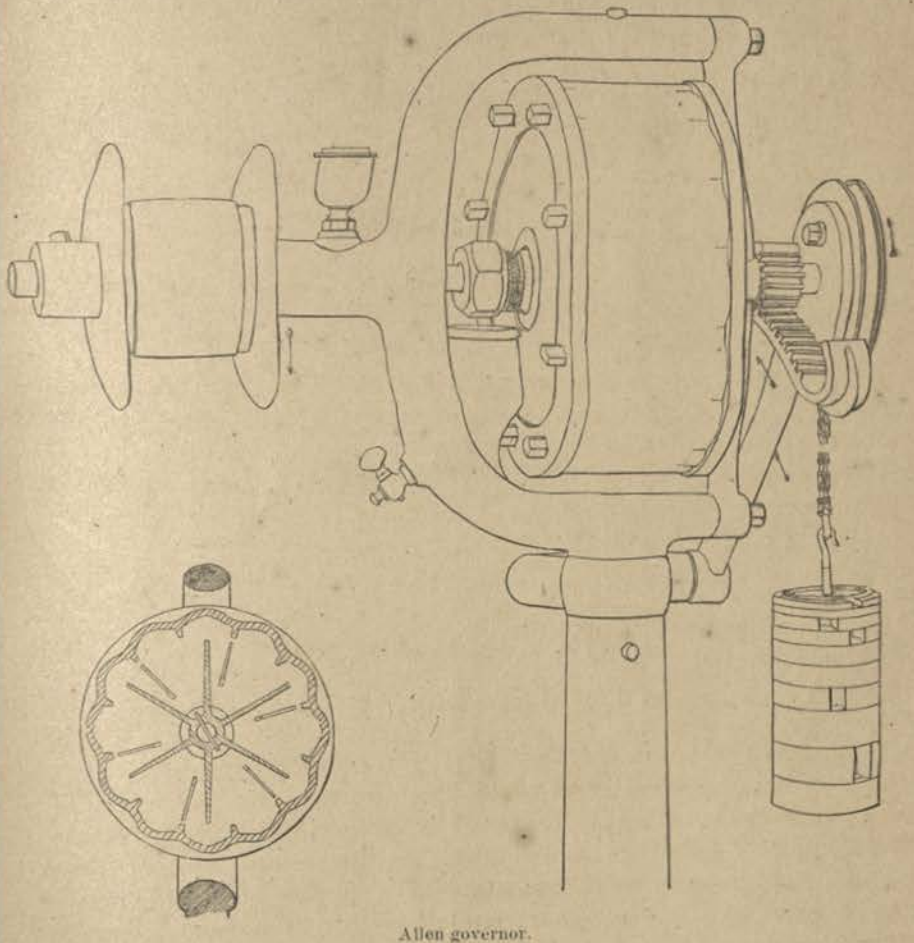
This differs from the ordinary compound belting in the fact that the center of the compound belt is built up of the soft outer portions of the hide, while the outer edges are made of the less extensible portions lying along the backbone of the animal. By this means the belt is said to adapt itself more readily to the convex surface of the pulley and the edges to afford the necessary lateral support to prevent the middle from stretching as much as it otherwise would, thus giving an even bearing to the whole breadth of the belt. Cutting the hide into sides enables the currier to work out any uneven or lumpy portions along the backbone.

Alexander Bros., 410 North Third street, Philadelphia.

ALLEN GOVERNOR.

Within a corrugated cylinder, which has small projecting ribs on its interior periphery, and which is partially filled with oil, a paddle-wheel is caused to revolve by a spindle passing through one end of the cylin-

der, driven by a belt communicating with the fly-wheel shaft. The tendency of the revolving paddle-wheel is to cause the cylinder to move in the same direction. On the side opposite to the revolving spindle is a trunnion or short spindle fixed to the cylinder, but free from the spindle; attached to this is a wheel carrying a set of movable weights suspended by a chain, which tend to turn the cylinder in a direction contrary to that in which it is impelled by the revolving paddle. The speed of the



Allen governor.

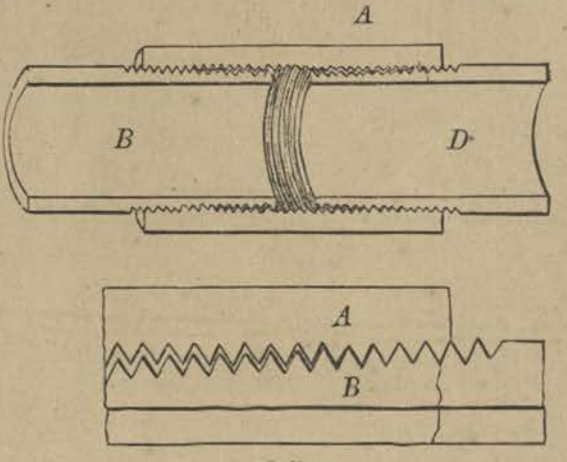
engine is regulated by the number of weights. Attached to the wheel and keyed on the end of the short spindle is a pinion revolving with the cylinder, and working in a toothed sector. The arm of the sector being fixed on the spindle of the throttle-valve, opens or closes it as the oil cylinder moves with the paddle, according to the variation of the load thrown on the engines. When used with variable cut-off engines, the arm is attached direct to the cut-off. If the speed of the engine is unduly increased, as in throwing off in a rolling-mill, the cylinder gains on the weight, tending to shut the throttle. When the work is going

through the rolls and the engine tends to slacken its speed, the weight gains on the cylinder and opens the throttle. The stop-valve can thus be left open all the time whatever variations of work may be expected.

The advantages claimed for this governor are its extreme sensitiveness and quickness of action. The weight acts in a vertical line and with a constant force.

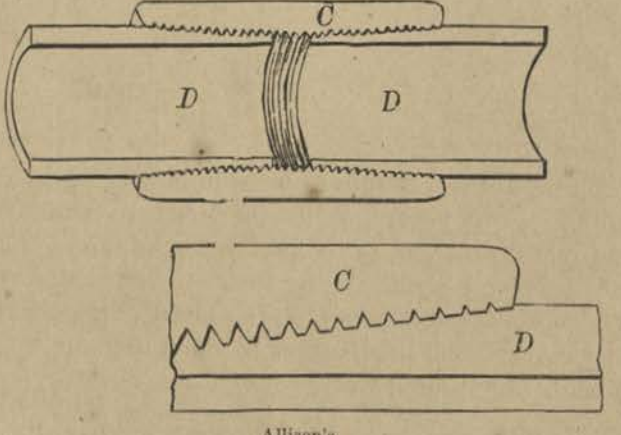
ALLISON'S PIPE-COUPLING.

The ends of the tubes are made conical and cut with a thread diminishing in depth up to the base of the cone. The coupling is cut to match,



Ordinary.

so that when screwed in there is a wedging-action tending to burst the coupling, which stiffens the joint and serves to bring all the surfaces to a bearing. This is said to be particularly valuable for drive-wells,



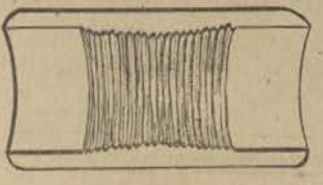
Allison's.

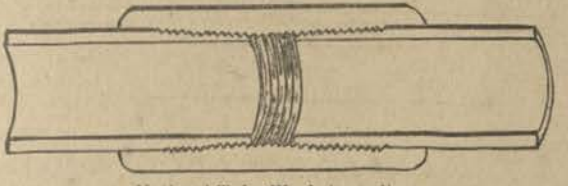
where in this case the shock of the hammer is taken from the thread and distributed tangentially on the coupling. The vanishing thread avoids the sharp notch near the end of the coupling found in threads of full depth throughout, which is a point of weakness.

W. C. Allison & Co., Philadelphia.

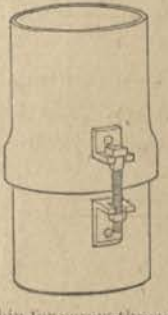
NATIONAL TUBE WORKS' COUPLING.

The principal feature (not shown in this sketch) consists in the use of counter-bored recesses at the ends of the couplings, to guide the pipe in entering the coupling and prevent crossing threads. These counter-bores extend over the body of the pipe, helping to "fish" the joint. The ends of the tubes are conical, with threads of equal depth.

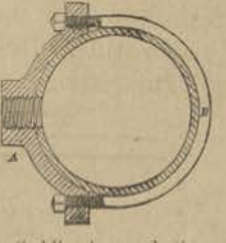




National Tube Works' coupling.



Pipe too thin for screw-thread.



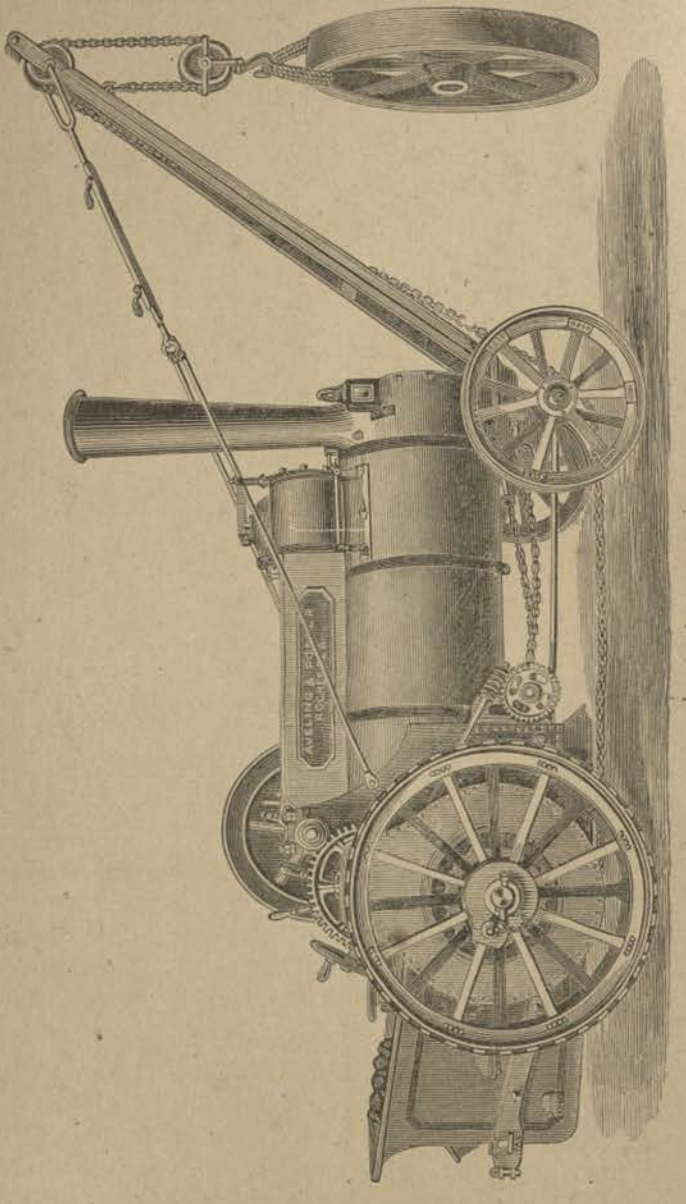
Saddle-piece and stirrup.

The sketch represents couplings for thin pipes such as are used in hydraulic mining in the West. When the pipe is too thin to take a screw-thread, one end is enlarged to receive the next joint. The two joints are united by a clamp screw joining the knees, riveted to the pipe. For right-angle joints a saddle-piece, A, is placed over the pipe and held by the stirrup B. The saddle-piece is perforated and tapped out to receive a pipe of any desired size.

AVELING & PORTER'S ROAD LOCOMOTIVE.

Two of these useful engines were in frequent operation before the opening of the Exhibition, engaged in the transportation of materials of all kinds for the British commission. They appeared to work easily and without hindrance, both by drawing wagons loaded with stores

and by carrying weights up to 2 tons upon the cranes projecting from their fronts. They are particularly well adapted to work on muddy ground. A 6 H. P. road locomotive, tried by Prof. R. H. Thurston, at

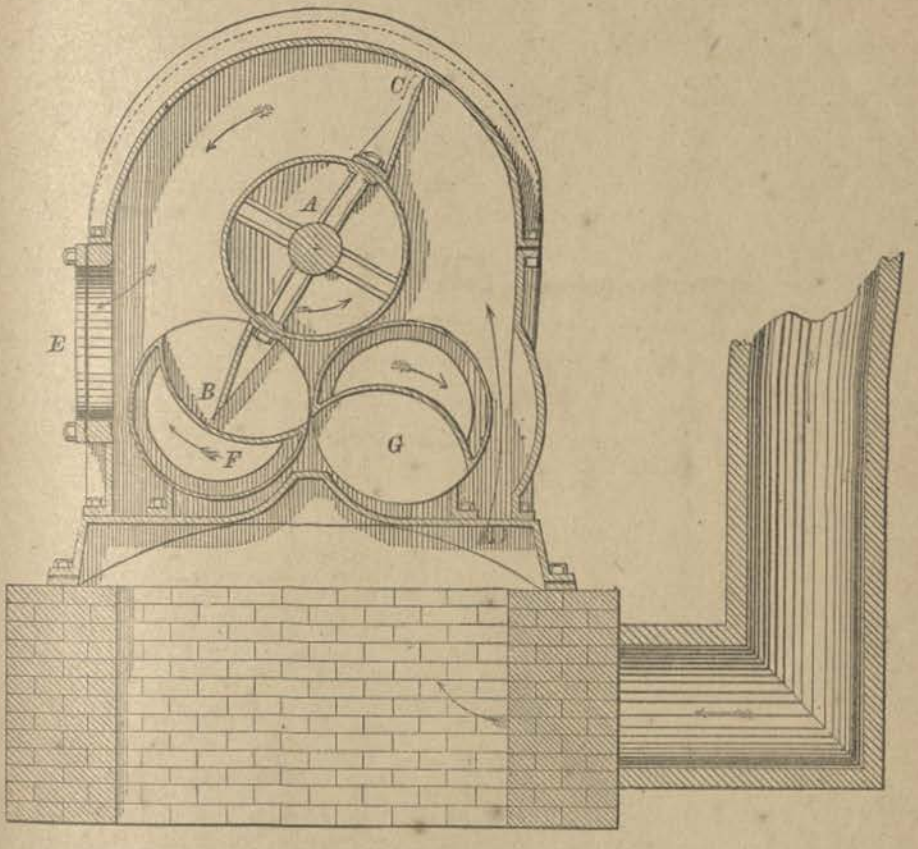


Locomotive crane engine.

South Orange, N. J., is reported to have drawn over 63,400 pounds 1,435 feet up an incline of 225 feet per mile without trouble. It is calculated that it performed the work of between 20 and 30 horses.

BAKER PRESSURE BLOWER.

This consists essentially of a rectangular case with semicircular top, within which revolves on a horizontal axis a fan with two straight radial vanes, B C. These vanes, of about one half the radius of revolution in length, are bolted to a cylindrical drum, A, which extends, as do the vanes, between the two sides of the case. This drum is mounted directly upon the driving shaft. Beneath this drum are two abutment



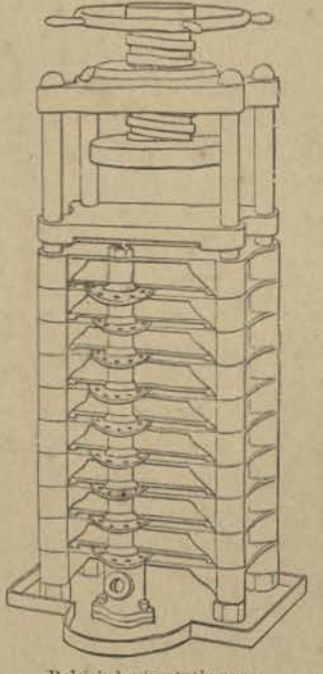
Baker Pressure Blower.

drums, F G, revolving in a direction opposite to that of A by means of gearing outside the case driven from the central shaft. These two drums are crescent-shaped in section, a portion of the exterior cylindrical sides being removed to allow the passage of the vanes. The vanes pass over the interior cylindrical surfaces, just clearing them. These abutment drums, by their contact with the two straps of angle iron, crossing the case beneath them, and with the periphery of the central drum above prevent the reflux of the air drawn through the inlet D, and direct it through the outlet E. It is allowed for them, in the report made by the judges of the Franklin Institute, that they are strong, durable, and simple, that they work easily and without great pulsation, that they can be

run directly from an engine, and being entirely metallic are unaffected by dust, dampness, or hot air, neither do they require internal lubrication or stuffing. The internal friction is slight, as the contacts above referred to are only approximate. The blower is made by Wilbraham Bros., Philadelphia, of seven sizes for No. 1, which costs $200, and delivers 3.5 cubic feet per revolution, to No. 5½, which costs $750, delivering 30 feet per revolution. Nos. 6 and 7 deliver respectively 45 and 60 feet. The smallest size will melt ¾ to 1¼ tons of iron per hour, and the largest from 13 to 20 tons per hour.

BOLAN'S HYDROSTATIC PRESS.

This consists of a series of extra stout rubber bags connected with a vertical water-pipe by means of short, hollow arms projecting from the sides of the bags, through which the water-pipe passes. These bags lie between iron plates cupped out to fit the bags, and sliding on four vertical iron posts which pass through the corners of the plates. Water may be admitted to the bags at a pressure of say 50 pounds per square



Bolan's hydrostatic press.

inch, due either to a normal head of water or to the admission of steam in a closed water-tank at any height. Supposing that there are ten bags, each 10 inches square, each one would exert a lift of 10 by 10 by 50 = 5,000 pounds, giving a total pressure for the ten bags of 50,000 pounds. As this pressure is exerted over a very short path, a heavy screw is provided by which the work may be set firmly against the top plate before the water is turned on.

The advantage claimed for this press is its speed and simplicity in operation, there being no valves or friction surfaces to get out of order, and nothing being required to put it in operation but to open the necessary valve. It is said the rubber bags do not leak. It is principally used for making corundum wheels, pressing celluloid fabrics, embossing leather, &c.

It is manufactured by Bolan Bros., Plane street, Newark, N. J.

BRAINERD SCREW-LATHE.

This machine, made by the Brainerd Milling Machine Company, Hyde Park, Mass., possesses several new features. It is provided with a cast-iron standard to be bolted to the floor. This standard furnishes many conveniences, such as drips, tool-closet, &c.

The turret-head (tool-post) is swung on two centers revolving on trunnions about a horizontal axis, which is coincident with that of the cylinder in which the turret-head is formed. These double bearings give the turret-head much greater solidity than where supported, as is usually the case, upon a single central axis either horizontal or vertical.

The cutting-tools are arranged radially in the periphery of this turret-head, so that all the strain from the work is brought directly upon the bearings. The trunnions rest upon a carriage, which by a horizontal lever may be approached to the revolving wire or withdrawn from it. By drawing it back to the full extent, a pin on the further face of the turret-head, entering a curved slot in a vertical surface connected with the bed-piece of the lathe, causes the turret-head automatically to make a one-sixth revolution. This brings the next tool in turn opposite the wire. The turret-head is held firm after turning by a beveled spring-pin through the rear side of the carriage, entering one of a series of holes on the near side of the turret-head. When the lever is drawn back to the full extent, the turret-head may be turned independently by hand. When the lever is drawn back, by means of a connecting-rod passing under the carriage, the feed at the left end of the lathe is actuated. The feed consists of a short cylindrical piece of steel pierced with an axial hole a little larger than the wire to be cut. The edges of this hole are quite sharp. To this hangs a stem, like the handle of a hammer, which is hinged to the connecting-rod. When this hammer-shaped piece is at rest, it lies back obliquely across the wire, touching it on the right-hand lower edge of the axial hole. By giving it a quick motion toward the lathe, as is done by the lever when the head approaches the work, the edge of the hob catches on the under surface of the wire, and slides it along through the live head to the desired extent; it then falls back for a fresh hold. The turret-head by the same motion is brought up to gauge the protruding end for length. The wire is clamped in the live head by a lever chuck in the live head, which binds the wire without requiring the stopping of the machine. The usual cutting-off device is applied. The lathe need never be stopped, except for cutting threads by hand. The machine costs $450.

The same company exhibits a universal milling-machine, the "Standard," which possesses some valuable adjustments for cutting mills, gear-wheels, drills, &c. The construction is too complicated to be described in this report.

BRYANT'S SELF-LUBRICATING PULLEY.

A recess about the hub of the pulley contains the oil, which is kept from running out by means of a sponge pressed over the orifice by a spiral spring. The centrifugal force in running, aided by the natural jar, throws up the spring sufficiently to allow the oil to run out in small quantities. When at rest there is no escape of oil.

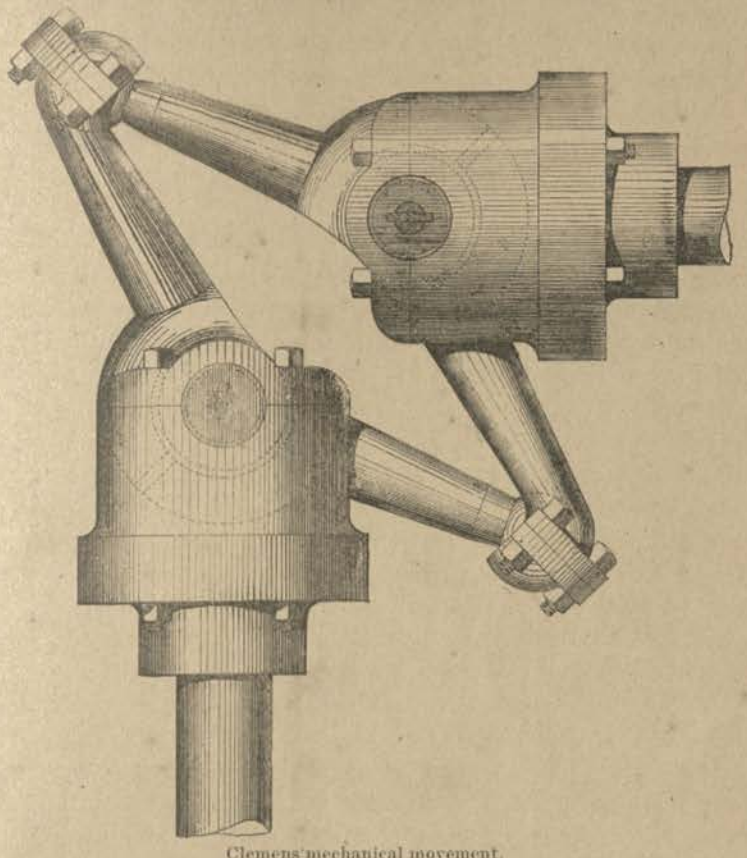
CARTRIDGE-VARNISHING MACHINE.

A wheel about 2 feet in diameter, 2½ inch face, revolving with an intermittent motion on a horizontal axis, is perforated near its rim with 40 holes parallel to its axis. These holes contain bushings revolving loosely within them, and reamed out to receive the cartridge from the front. In front of this wheel and above it is a hopper in which the cartridges are loosely thrown. Revolving in this hopper is a picker, consisting of three L-shaped hooks arranged upon a horizontal shaft across the hopper. When the machine is set in motion the ends of these hooks catch in the mouth of the empty cartridge shells, and carry them singly to a pipe, which enters the hopper on the side next the wheel. On reaching the proper position the shells fall off the hooks into the pipe, heads downward. The cartridges are discharged one at a time through the lower end of the pipe, into a box just opposite the lowest point of the wheel. This box is so made that, as the cartridge falls into it, it is compelled to assume a horizontal position with the mouth next to the wheel. A plunger in rear passes the cartridge into whatever chamber happens to be opposite to it at this moment, and then retires to receive a fresh cartridge. The next impulse of the wheel brings the cartridge opposite to a revolving varnish brush on a spindle in rear of the wheel and at right angles to it. By a cam motion this brush is passed into the cartridge case to the bottom. It is withdrawn just before the wheel moves on; another revolving brush, charged with alcohol, then enters the cartridge to the distance occupied by the bullet, and wipes off the varnish where it might adhere to the patching, &c. When not in the cartridge shell these two brushes rest upon rollers covered with flannel, which rotate in pans of varnish and alcohol respectively. After the mouth of the cartridge is wiped, it makes nearly the entire circuit of the wheel, the bushing on which it revolves turning on its own axis, meanwhile, by means of a small gear cut on the inner end of each bushing, which engages with a fixed annular gear concentric with the axis of the wheel. This distributes the varnish uniformly. Just before the cartridge shell has arrived at its original point of entrance, it is pressed out by a plunger in rear, operating parallel to the brushes and in the

same manner with them. The cartridges are then to be thoroughly dried in an oven before loading. The machines varnishes 2,000 per hour. It weighs 1,800 pounds, and costs $1,600.

Pratt & Whitney, Hartford, Conn.

CLEMENS MECHANICAL MOVEMENT.

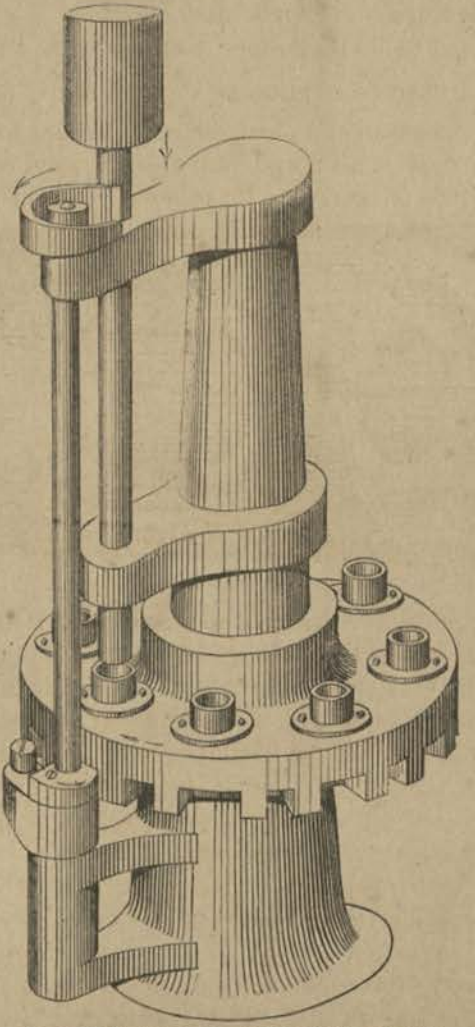


Clemens mechanical movement.

This is intended for transmitting rotary motion around corners as a substitute for bevel gears, double belts, &c. The advantage claimed is that the arrangement is positive and at the same time flexible, not requiring the nice adjustment necessary with bevel gearing. It is also noiseless. Each shaft, as shown, is provided with two equal arms revolving on hinges formed in cylindrical heads on the contiguous ends of the shaft. The arms are connected in pairs by ball and socket joints. Their ends next the shafts revolve on hollow journal pins, and are balanced to preserve uniformity in their rotation and vibration by counterpoise masses cast upon their inner ends. The necessity for this becomes evident on considering how much further away from the axis of rotation the center of gravity of the arms are in the inside position than the outside. The arms are hollow, carrying by centrifugal force the oil from the hollow journal pins to the ball joints outside. Motive power being applied to rotate either shaft, the inner ends of the arms

will revolve with their respective shafts, while the outer ends of the arms will revolve in their diagonal circle of rotation, which compound rotary movements cause the arms to vibrate, both on their pivot pins and at their ball joints, with equal pivot movements, the arcs of vibration at each pivot being, in each revolution of the shafts, equal to the angle of deflection of the coupled shafts. The angular velocities of the two shafts are evidently the same at all points of a revolution of them, when we consider the arms of each opposite pair as equal levers in all their positions during a revolution. This vibration becomes evident if we imagine the shafts detached from each other on the ball joints and consider the arms rigidly fixed to the cylinder heads, then imagine a half turn given to the shaft. It will be seen that in the case under consideration the new position of either arm would be at 90° to its actual position in practice.

Melville Clemens, care of George V. Cresson, Philadelphia.



Cooper's intermittent gearing. (See page 893.)

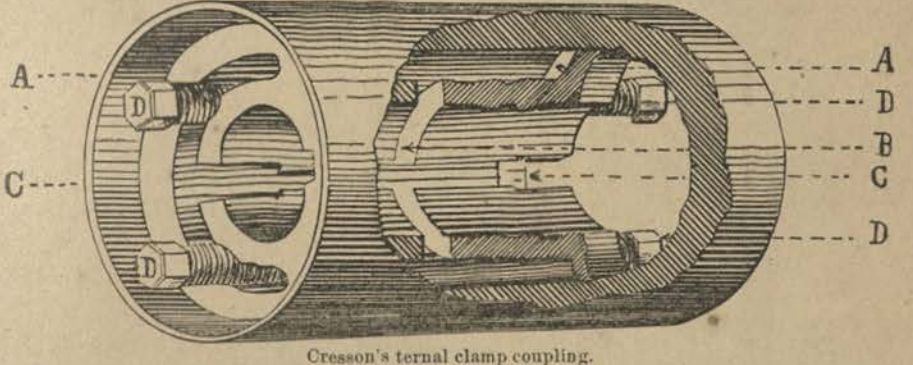
COOPER'S INTERMITTENT GEARING FOR STAMP MILLS, &C.

The upright spindle is driven by a bevel gear from below; near its lower end is a horizontal arm, bearing at its outer end an upright roller. As the spindle revolves this arm enters into one of the alternate narrow notches of the table and gives it one-eighth revolution, bringing one of the dies beneath the stamp. The upper end of the spindle is formed into a spiral cam which engages under a notch cut near the head of the stamp shaft. This causes the stamp to rise bodily as the spindle turns. By the time the upright spindle has finished its work of turning the table, the broad part of the horizontal arm near the axis has come into one of the wide alternate notches in the edge of the table; as this end of the arm is formed into a vertical cylinder it holds the table immovable during the continued further lifting of the stamp, which at this moment is nearly completed. The end of the cam being reached, the stamp falls into the die, the fall of the blow being transmitted through the head of the arm to the frame of the machine.

This is exhibited by J. H. Cooper, Germantown, Philadelphia.

CRESSON'S INTERNAL CLAMP COUPLING.

The coupling is cast in one piece, being cored out to form the grooves A A B. When cast it is bored out a little smaller, say 0.001 inch, than the shafts it is to receive. It is then slotted through in the groove

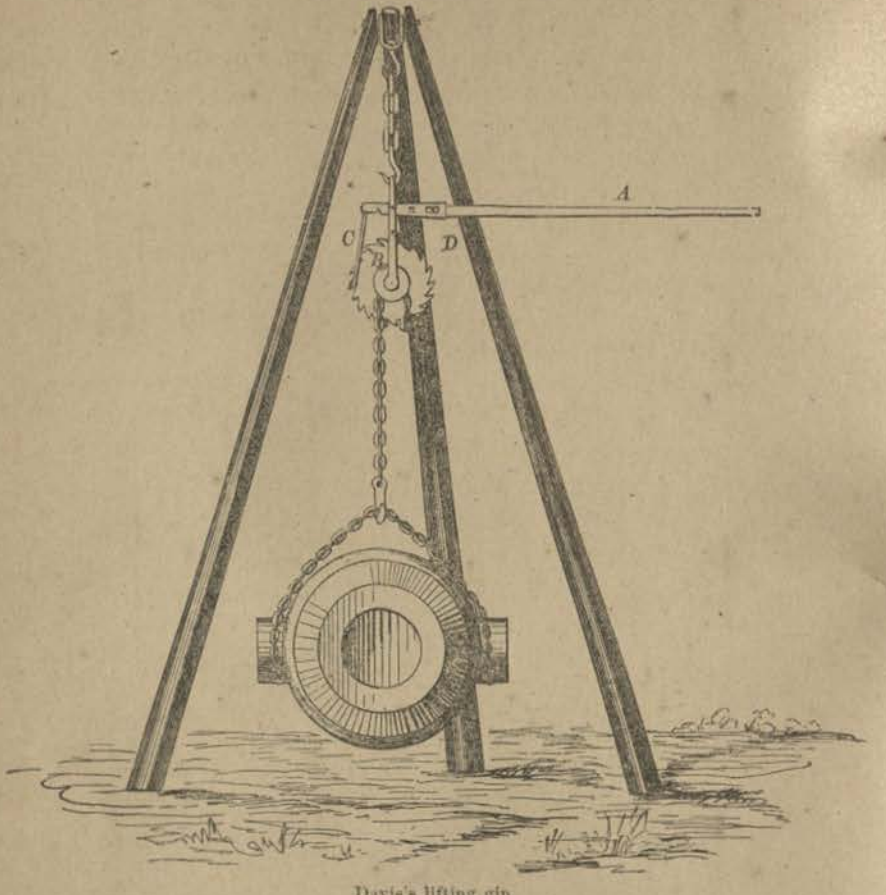


Cresson's ternal clamp coupling.

C, and drilled and tapped for the taper-screws D D D D. The effect of the slotting is to cause the cored sides of the hole to spring, allowing the shafts to enter freely. When placed upon the shafts, the taper-screws are turned in, causing the clamping parts to press inward upon the shafts, firmly binding each shaft along the length covered by the coupling, and in a manner independent of the diameter of the other shaft. This is done without great strain upon the bolt. For shafts of greatly-varying sizes a coupling with two different bores is used. The internal clamp-hub operates on the same principle. By boring the wheel a little smaller than the shaft and then opening the clamp by wedges just enough to allow the shaft to pass through the hole freely, a forcing fit may be obtained at any point by merely removing the wedges. The set-screws also aid in perfecting the grip, though they

are not indispensable. They do not bear directly upon the shaft, but on the clamps. In the case of the hub they are of uniform size and enter radially.

DAVIS'S LIFTING GIN.



Davis's lifting gin.

The lever A is connected with the ratchet wheel B, by means of the swinging stirrup C, at its farther end. The pawl D keeps the wheel from running back. C and D are so proportioned that only one of them can bear at a time upon the ratchet wheel, so that in letting down the weight they are alternately released, the strain being taken off the pawl by lowering the lever, and the stirrup being set for a fresh hold by raising the lever. The lever has an adjustable fulcrum. The periphery of the chain wheel is provided with link sockets to prevent slipping. The machine shown and used is a stump and rock extractor; it has a lever power of 1:133. Its cost is $40.

A. C. Colton, Vineland, N. J.

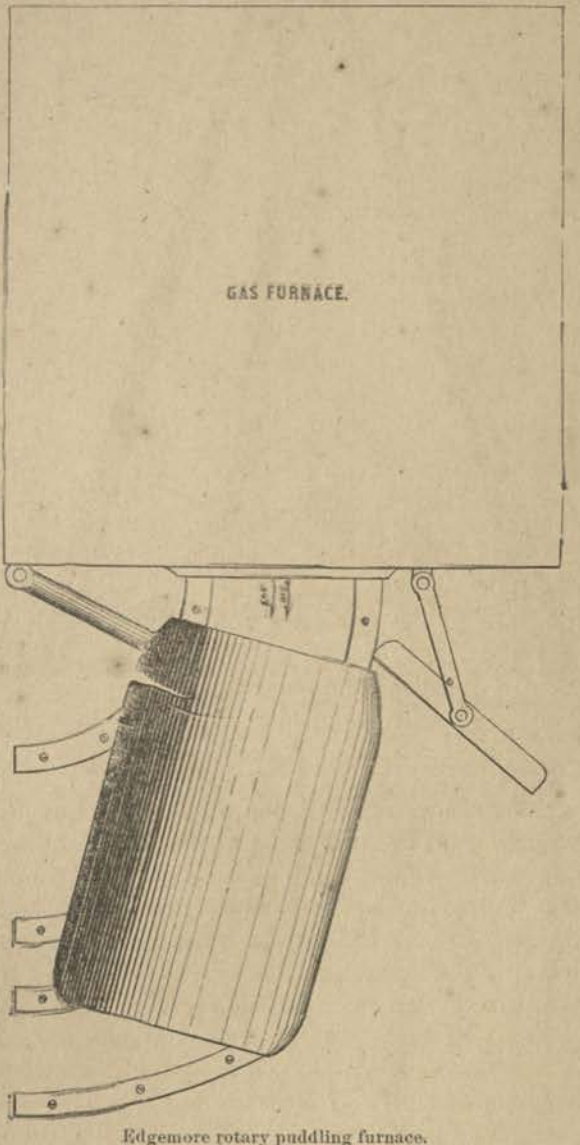
ECCLES PIVOT CENTER.

This is designed especially for turn-tables, swing-bridges, &c. A sufficient number of conical rollers lie between the turning plate and the bed

plate; at about half their length a geared belt is formed which engages with flat circular geared rings in the contiguous surfaces of the plates. In consequence the rollers are compelled to revolve when the upper plate is turned, and they are kept from changing their relative positions. The rollers only bear upon their smooth parts.

EDGEMORE ROTARY PUDDLING FURNACE.

To be used in connection with the Pousard furnace is shown a rotary



Edgemore rotary puddling furnace.

puddling furnace resembling in some respects the Dank's furnace described in Chief of Ordnance Report, 1876. In this furnace, the horizontal puddling barrel is only open at one end, and is entirely separate

from the furnace itself, swinging bodily away from it like a door to open, and shutting against it when closed. The mixed air and gas issue together from the mouth of the furnace, and making a complete sweep of the inside of the barrel escape by an aperture in the face of the furnace close by their entrance. (It will be remembered that the puddling barrel of the Dank's furnace is stationary and open at both ends, the flame passing directly through it and then out by a swinging sectional flue, which communicates with the smokestack; this sectional flue is swung aside when it is desired to gain access to the interior of the furnace.) Back of the puddling barrel and on the same frame with it is a small engine by which the barrel is revolved, or at pleasure swung around from the face of the furnace; a special arrangement of water circulation, passing through the hinge which connects the barrel with the face plate of the furnace, protects the joints from warping or burning. The barrel moves with rollers on raised circular rails whose center is in the hinge above mentioned. On the other side of the flame hole is fastened to the face plate of the furnace a vertical saucer-shaped iron door, lined with fire-brick. This is swung on a frame provided with two vertical hinge joints, by which it can be brought against the flame hole, preventing the escape of gas into the room without interfering with the ready passage of the flame through the flue system of the furnace.

FAIRBANKS TESTING MACHINE.

Fairbanks & Co. show a very ingenious attachment to their testing machine by which the final counterpoise is made to travel along the beam in the direction of the ascending numbers, by the act of applying the testing strain to the specimen under trial. This is effected by a cord connecting the counterpoise with clockwork at the outer end of the beam. This clockwork is usually held stationary by means of a horizontal lever above it provided with a tooth on its lower side. This tooth is engaged with the teeth of one of the system of wheels by means of a weight on the inner end of the lever. When the application of the strain causes the beam to rise, the outer end of the trigger strikes a cross-bar which disengages the tooth on its under side from the teeth of the wheel, and permits the clockwork to draw the counterpoise up the beam. When the counterpoise balances the strain applied to the specimen, the beam drops, the weighted end of the lever engages with and stops the clockwork, and the counterpoise automatically comes to rest at the point which indicates the strain applied.

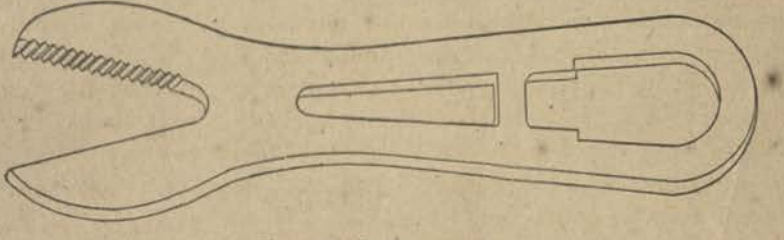
FILE-TESTING MACHINE.

This machine is used by the American File Company, of Pawtucket, Rhode Island, for testing the cutting qualities of their files. A horizontal bar is given a horizontal reciprocating motion by means of a revolving wheel in a slot through which plays a yoke and pin. To the un-

der side of each end of this bar is clamped a file. Beneath each file stands vertically a flat bar of the material to be filed, with its end resting against the face of the file. This material is usually a strap of wrought iron about 1 inch by $\frac{1}{16}$ inch, about 36 inches long. It is clamped at is lower end to a graduated wooden scale, which rises through a hole in the table near the top of the iron bar. The pressure of the file upon the material is brought about by inversion, by causing the bar to be raised against the file, by means of a weight suspended under the table, and connected by cord and pulleys with the lower end of each bar. By means of this weight the scales at each end of the table are caused to rise as the top of their respective bars are filed off; and by comparing the emergence at the two ends of the table, the respective duties of the two files under comparison may be ascertained. A small roller above the pressing point of each file receives the thrust of the weight. A cam upon the inner surface of the wheel at each half revolution strikes a tripper connec ed with each bar and drops it below the reach of the file on its back stroke. It raises the bar by the same means in season for the next advance of the file. In a trial seen by me, the American file gained perceptibly on its contestant, an English hand-cut file.

FLANAGAN'S SAMSON WRENCH.

This consists of a flat bar, having at one end a V-shaped notch the sides of which are serrated with teeth set obliquely to the sides of the



Flanagan's Samson wrench.

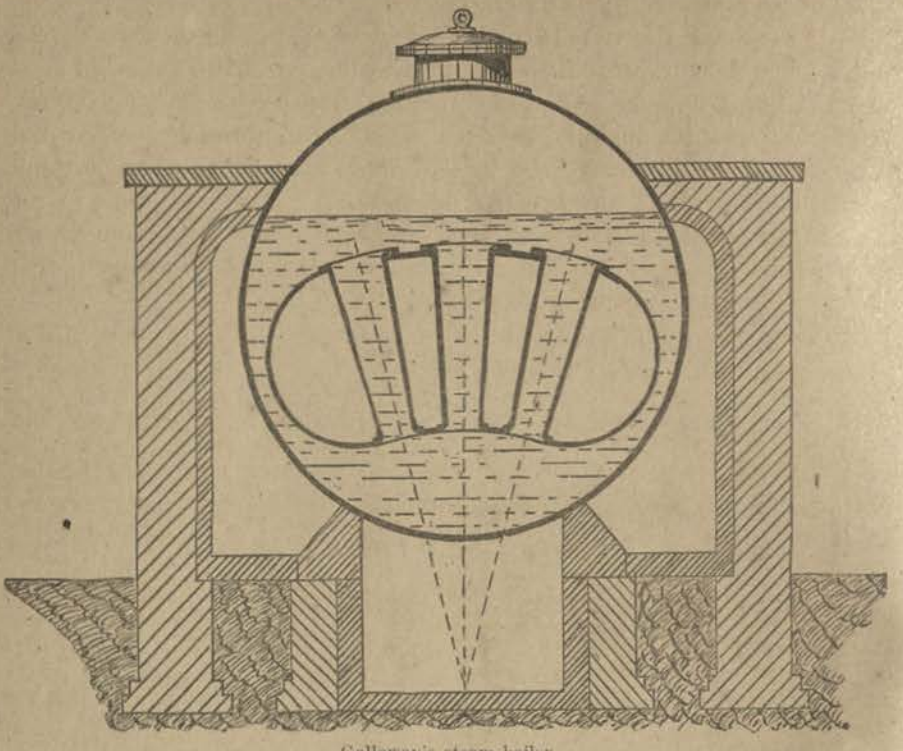
wrench. In consequence of this the teeth "draw" into the material of the pipe or nut which they grasp, and hold it all the tighter for the pull. The jaws diverge for different sizes of work. Small wrenches have holes punched in the handle for small nuts, &c.

W. J. Flanagan, 32 North Fifth street, Philadelphia.

GALLOWAY'S STEAM BOILER.

This boiler, which is now very extensively used in Great Britain, depends for its economy, strength, and durability, upon the use of large vertical or alternating diagonal water tubes, traversing the body of the main flue or flues of boilers of the Cornish type. The sketch of the water tube shows how easily it can be applied. The *outside* diameter of the flange at the small end is the same as that of the body of the tube,

at its largest end, *inside* the flange. Consequently, a hole being cut in the top of the boiler large enough to receive the small flange, when the



Galloway's steam boiler.

tube is passed in a tight joint will be formed around the large end of the tube underneath its flange. When both flanges are riveted and the hole carried through the bottom of the boiler the application is

Water tube.

complete. These tubes are said to stay the flues against collapse, and, by breaking up the current of fire gases to retain them within the flue and thus facilitate the generation of steam. They also promote the circulation of water. The tubes are welded and flanged from one piece

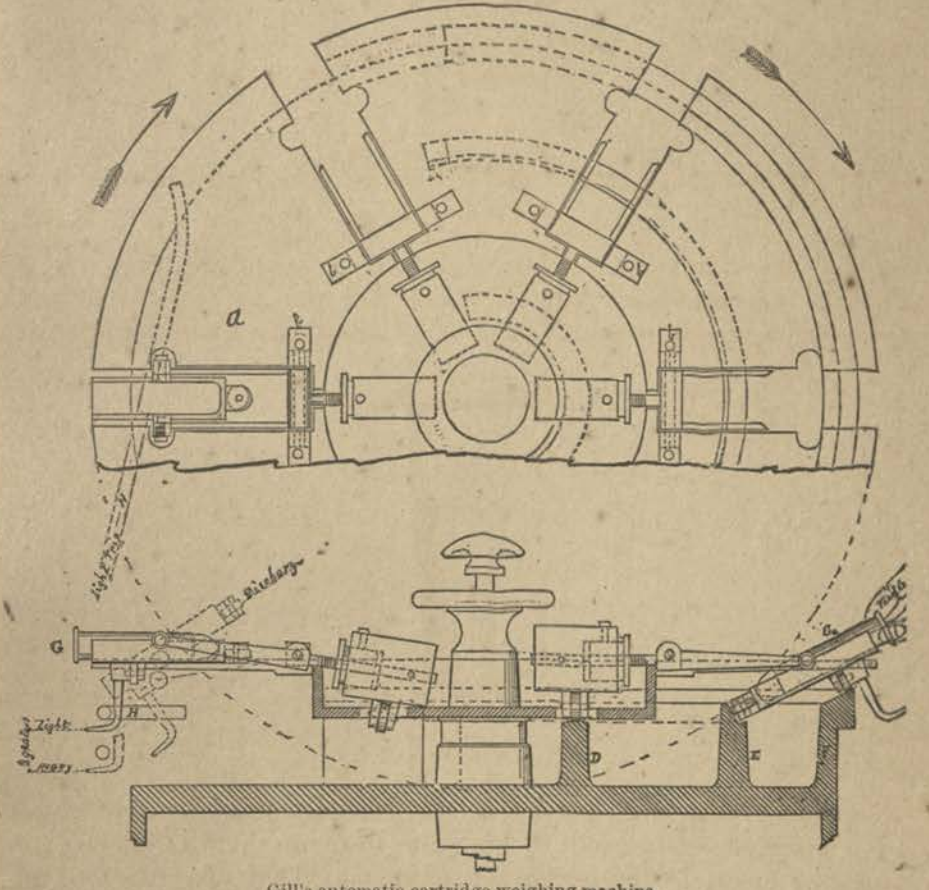
of iron. The three boilers shown are each 28 feet long by 7 feet diameter; 75 pounds pressure. Each one is capable of supplying steam to drive a 300-horse-power condensing engine.

The flue above shown constitutes the chief feature in the "Galloway boiler," which contains 33 conical water tubes, each 10½ inches diameter at the top or large end and 5½ inches diameter at the lower end, fixed in an upright position, in such a way as to support the flue and to intercept and break up the flame and heated gases when passing from the fire-grate or furnaces to the chimney. Along the sides of the flues there are also placed several wrought-iron stops or bafflers, which deflect the currents of heated air and cause them to impinge against the tubes, so as to absorb all the heat possible.

Tubes not exceeding 2 feet 6 inches long cost 35 shillings each, and up to 50 shillings for 4-feet tubes.

GILL'S AUTOMATIC CARTRIDGE-WEIGHING MACHINE.

The cartridges are fed by hand into the six counterpoised cradles carried around the central spindle by the rotation of the disk A. To avoid



Gill's automatic cartridge-weighing machine.

oscillation, the cradles and counterpoises run on rollers, upon ways formed on the base plate, at the feeding point and for a short distance on each side of it. These ways taper off gradually in the direction of the rotation until the balance remains perfectly free at both extremities. If then the cartridge be heavy enough for service, that is, does not weigh more than 3 grains less than the inferior limit of acceptable manufacture, a hook on the bottom of the cradle strikes the "heavy trip," and tilting the cradle deposits its load into a certain fixed receptacle. If the cartridge is light, the cradle is raised by the counterpoise above the "heavy trip" and so escapes it. It meets the "light trip" further on however, and is tilted at another point of the revolution into another receptacle. The machine will thus assort about 30,000 cartridges in a day of ten hours.

This machine, designed by Mr. Jabez H. Gill, master machinist of the Frankford Arsenal, was exhibited in the Ordnance Section of the War Department exhibit.

GOODWIN'S RECIPROCATING MOVEMENT.

This interesting device is shown upon a mowing-machine, and is designed to impart a rapid reciprocating movement to the cutter-bar without the use of cog-wheels of any kind. The arrangement is as follows: To the axle is keyed fast an angularly corrugated disk, A. Another precisely similar disk, B, is fastened to it by bolts *b*, *b*, *b*, *b* and an air-tight ring, C. Between these two disks is a third one, D, corrugated on both sides. This disk has a sleeve, *e*, projecting through B and connected with the cross-head E. This cross-head is pivoted between the arms L L of the lever, so that D cannot turn with A and B, and is only permitted a reciprocating longitudinal motion along the shaft. This motion is imparted to it as follows: Suppose A and B revolving together in the direction shown by the arrow. Say the point *x* on B strikes D as shown, the surfaces being smooth and lubricated, and D unable to turn, it will be shoved to the left in the direction shown by the arrow until its point is clear of *x*, but then it will be caught by the face *y* and shoved back again until caught by the face *z*, &c. These motions are conveyed by the cross-head to the lever, fastened at one end to the fulcrum F, a part of the general frame of the machine, and at the other end to the cutter-bar. G is a bumper, which strikes against India-rubber buffers on the frame of the machine to assist in reversing the motion at each stroke. The twenty ridges on each fixed disk give 40 strokes to the cutting-bar at each revolution of the wheel. The box containing the reciprocating disk being nearly air-tight, the air which it contains serves as a cushion for the disk and causes it to work without shock.

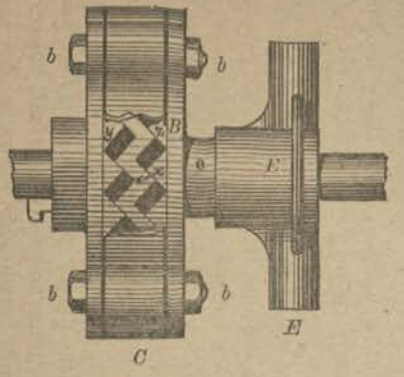


Fig. 3.

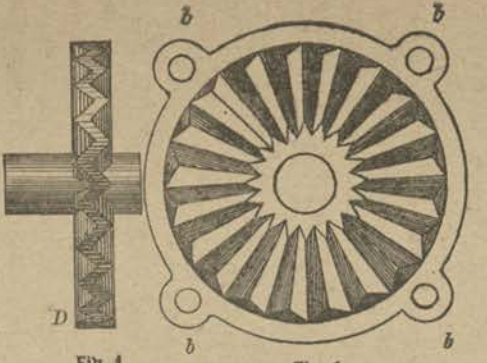


Fig. 1. Fig. 2.

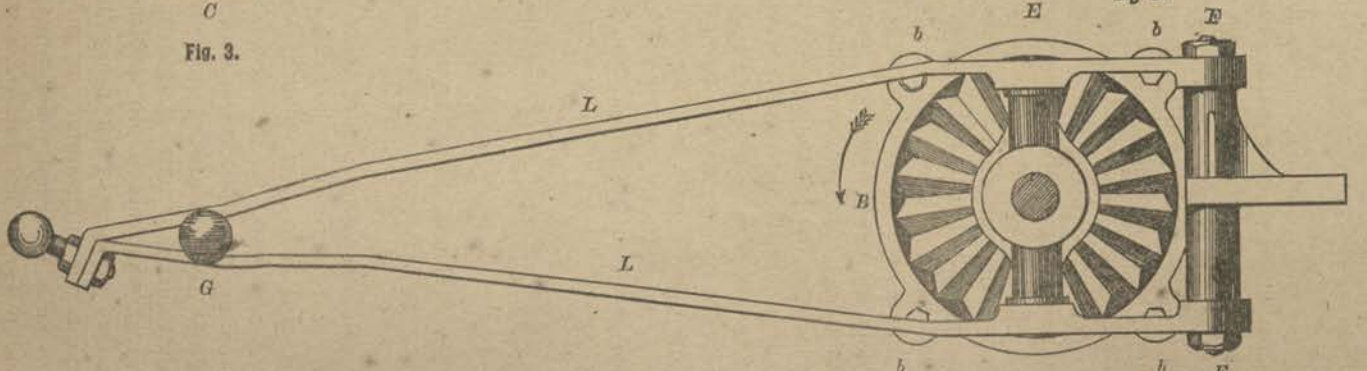


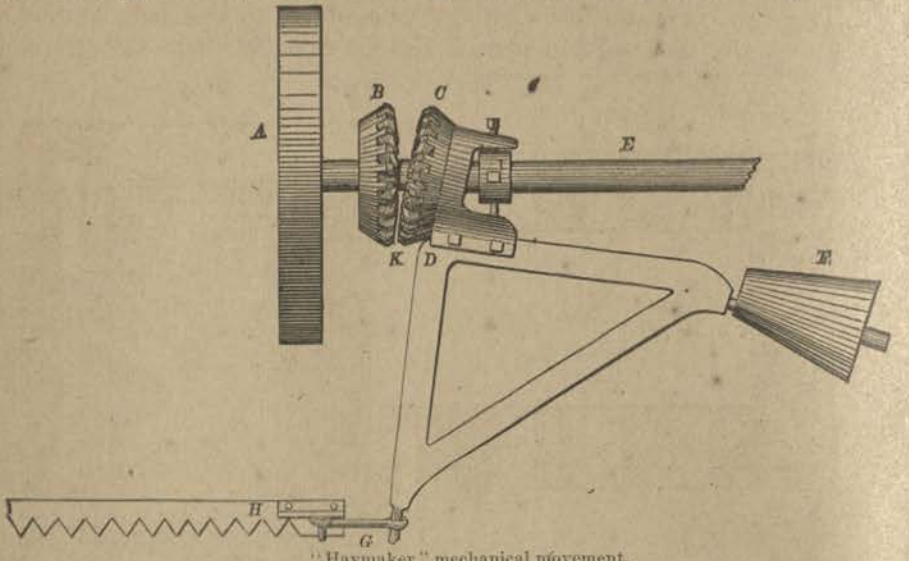
Fig. 4.

Goodwin's reciprocating movement.

"HAYMAKER" MECHANICAL MOVEMENT.

This exceedingly curious movement is shown upon a mowing-machine, where it serves as a device for transforming the rotary motion of the driving-wheel into a reciprocating motion of the cutter-bar.

In the sketch, A is the driving wheel; B a bevel cog-wheel keyed to the driving axle E; C a concave cog-wheel set obliquely to B upon the



"Haymaker" mechanical movement.

universal joint I. The shaft turns freely through I without causing rotation. To C is bolted a triangular frame, D, one end of which is connected by the connecting rod G with the cutter-bar, the other end bent downward enters eccentrically a conical drum, F, revolving in bearings upon another portion of the general frame of the machine. This drum serves as a fly-wheel.

The operation is as follows: When A is rotating, C tends to rotate also, on account of its engagement with the lower teeth of B, but in attempting to turn it causes F to turn with a crank motion which only succeeds in bringing another portion of C in contact with B. This motion draws the cutter-bar in the direction H G, by the revolution of the whole system C D, around its axis in I. The vertical axis of the universal joint permits a slight reciprocating play, which allows the wheel C, under the influence of the eccentric F, to engage in succession all parts of its circumference in the teeth of the continuously revolving wheel B.

The motion of C resembles that of the last turn of a plate or coin spun upon a table, supposing it always to cover the same circle, and not to revolve. Another illustration would be the motion given to a tumbler in trying to impress a circle of the same size as its mouth, by contact of successive portions of its rim with a flat surface. If a pencil be laid across the bottom of the tumbler under the fingers, and held there, its point will describe an eccentric ellipsoidal curve of double curva-

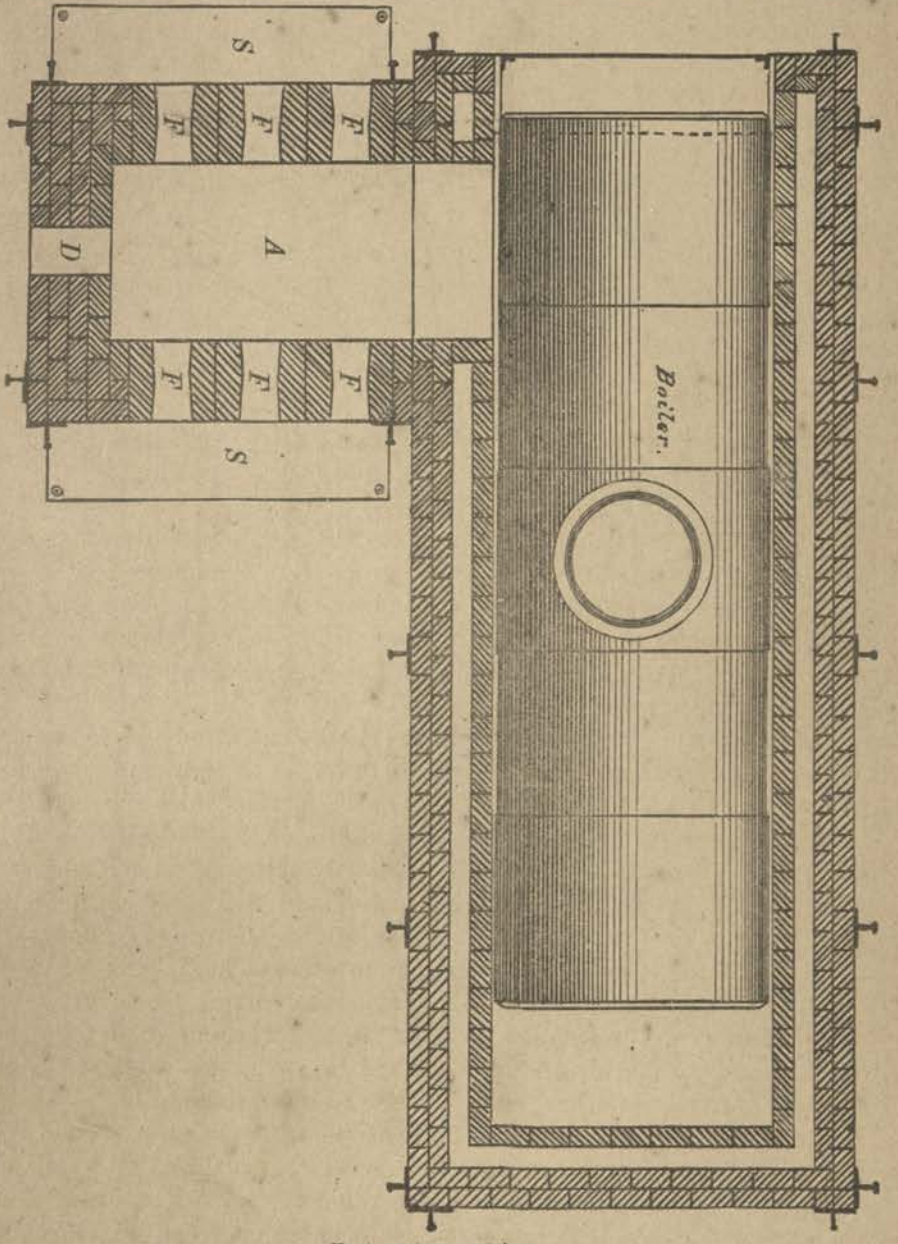
ture, which, by means of a connecting-rod, can be transformed into the reciprocating motion desired.

One "of the gear-wheels has more teeth than the other, to prevent their ever coming together tooth to tooth when thrown into gear."

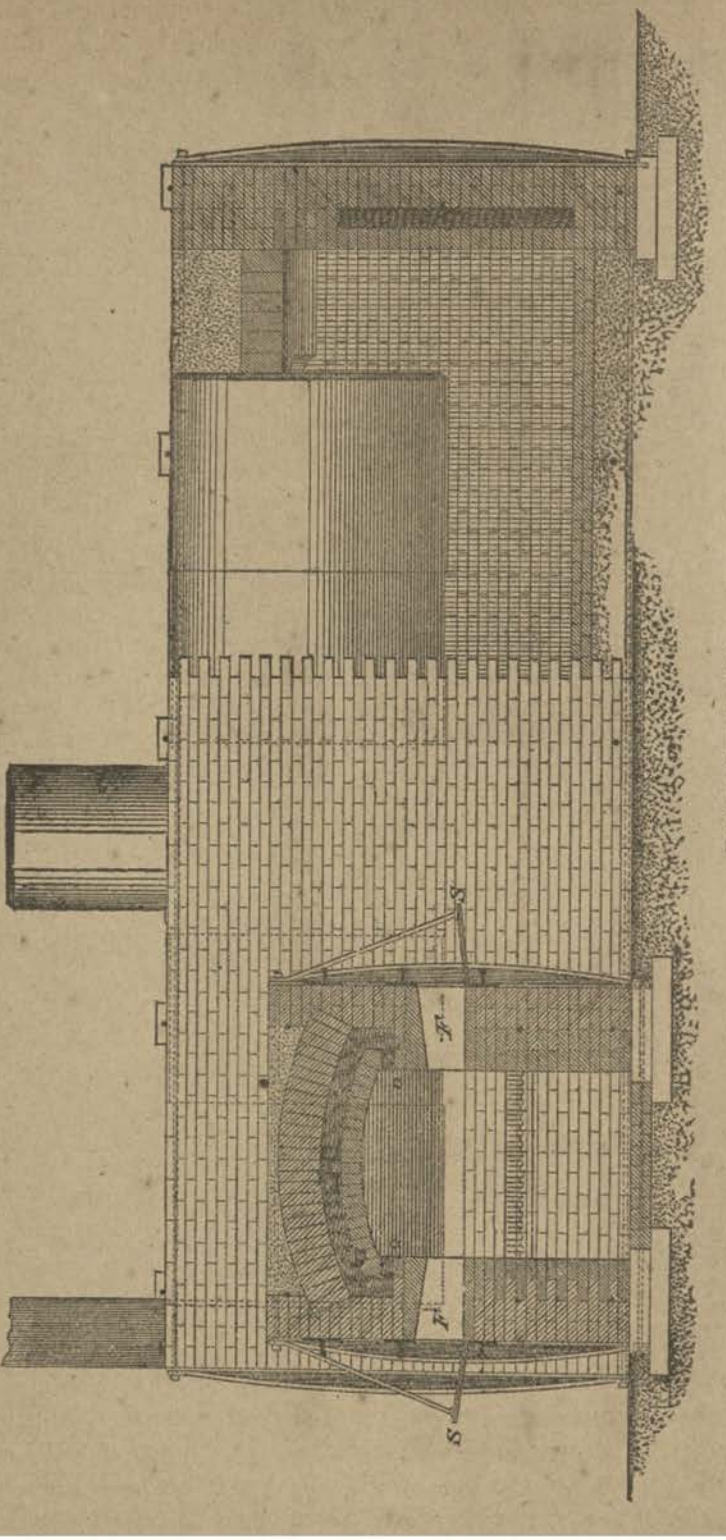
For clearness of illustration the wheels B C are represented out of gear.

THE HOYT GAS FURNACE.

The furnace shown is a simple application of the Siemens method of burning the gaseous products of the slow combustion of bituminous

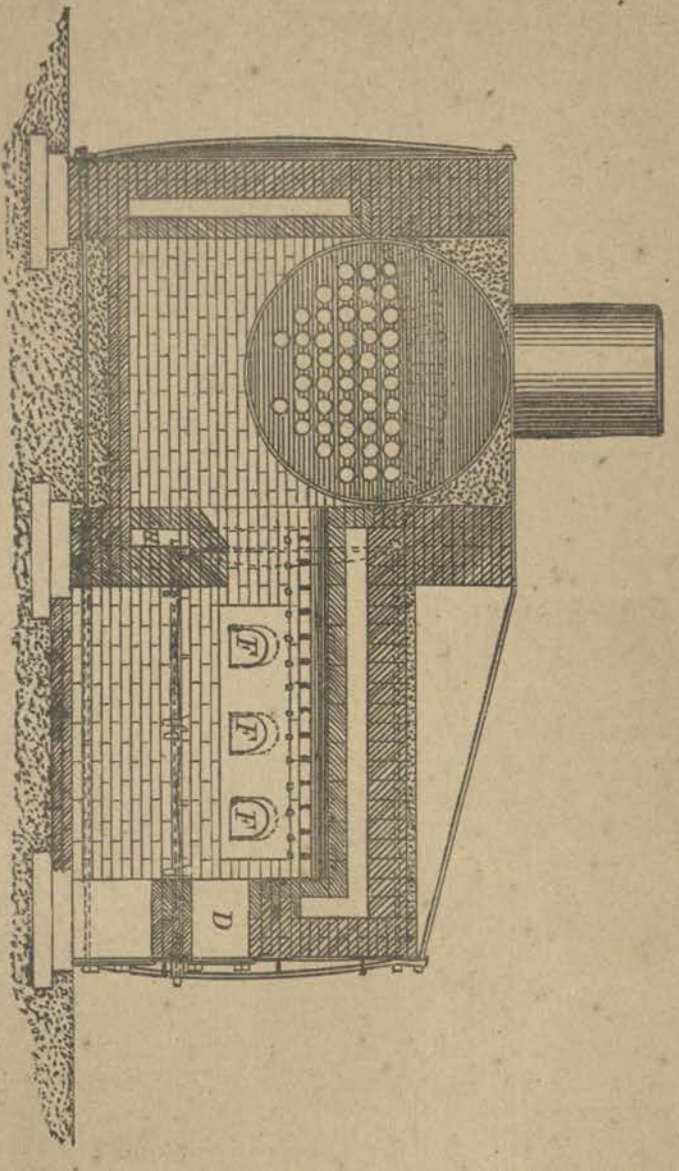


Hoyt gas furnace (plan).



Hoyt gas furnace (side).

coal, mixed with a proper proportion of superheated air. The peculiarity of the construction of this furnace is its compactness and simplicity of operation, and the fact that the coke itself, as well as the product of its distillation, adds the energy of its combustion directly to the flame.



Hoyt gas furnace (end section).

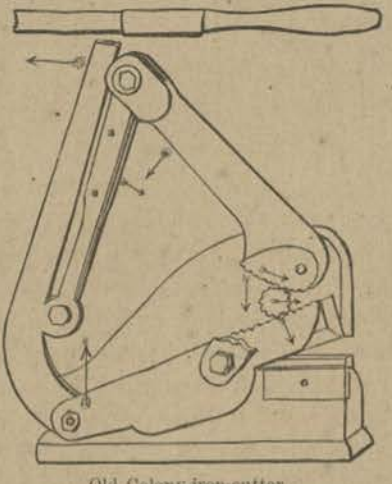
The coal, broken small, is fed from the shelves, S S, through the 6 feed-holes, F F, over which it is always kept banked outside. Within the furnace upon the grate, and reaching above the inner mouths of the feed-holes, is formed a thick bed of glowing coke, beneath the surface of which the coal is slowly poked in. As the coal approaches this hot

coke its gas is gradually distilled, and, by passing through the bed of hot coke above it, is heated to the point of eager union with the air required for its combustion. The air is mainly admitted through small openings, *o o o*, &c., above the feed-holes, and enters the furnace from hot-air flues, H H, &c., above the furnace and around the boiler. As soon as the air and gas meet in the furnace the gas is burned with an intense heat (about 3.500° F.). Air is also admitted through a number of small holes in the door, D, and through the interstices of the coal in F F F. The ash-pit door is never opened except to start the fire.

The coal, after rendering its gases to the flame, becomes coke, and by its own destruction assists in the subsequent distillation of fresh quantities of coal. Experiments made with this furnace and a common tubular boiler indicate its ability to burn without smoke 20 pounds of highly bituminous coal per square foot of grate per hour, evaporating 10.64 pounds of water at 212° per pound of coal.

One advantage claimed for this furnace is its economy with quick combustion and unskillful firing over those furnaces where slow combustion or great skill in firing is required to produce the best effect. Its consumption of smoke is notable.

OLD COLONY IRON-CUTTER.

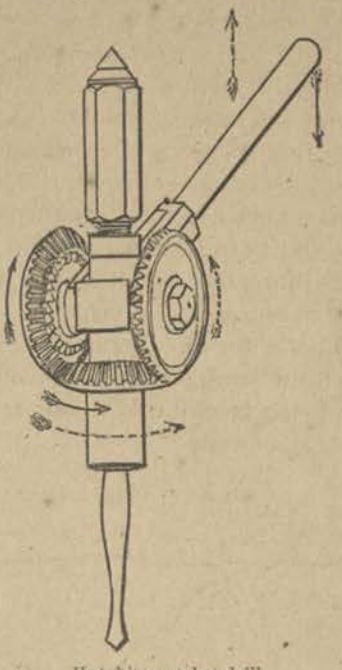


Old Colony iron-cutter.

The principal feature of this machine consists in a loose corrugated roller between the cam-shaped corrugated head of the working-lever and a similar corrugated rack on the upper side of the cutter-head. As the hand-lever is depressed the upper toggle is straightened and the cam caused to bear upon the roller. This causes the cutter-head to descend with a motion assisted by the lifting action at its other end. The roller serves to diminish the sliding friction between the two surfaces. An increase of power, due to the position of the roller, is claimed for the combination, but can hardly be allowed, as what is gained on the lower lever is lost on the upper.

HUTCHINS PATENT RATCHET DRILL.

Upon the shaft of the tool-holder is fixed a horizontal bevel-gear wheel with its face up. Upon the shaft above it is a sleeve with projecting trunnions, upon which revolve two more bevel-gears engaging



Hutchins ratchet drill.

with the horizontal wheel below. A circular ratched is formed upon the inner face of each of these two wheels, the teeth stopping in each wheel, in relatively opposite directions in consequence of the opposition of the wheels. The wheels are themselves alike. Between the two upright wheels, there passes a forked lever revolving independently upon the same axis with them. From its head, near the axis, issue laterally two spring ratchet pins, which engage with the circular ratchets referred to. The operation is as follows: When the handle of the lever is brought down as shown by the arrow, the ratchet pin on the right of the operator engages with its wheel, bears it down, and causes the horizontal wheel to turn forward. When the handle is raised as shown by the dotted arrow, the wheel on the left turns up and causes the horizontal wheel to revolve in the direction as before. The mechanism thus utilizes both motions of the hand lever, and gives a nearly continuous motion to the drill. It can also be used with the lever horizontal in the usual way. In this case both wheels are locked during the movement in one direction, and both revolve freely during the back stroke, losing one-half the full effect of the continuous motion described. This motion is comparable to that produced in turning the front wheels of a wagon with shafts, around a fixed king bolt. Ordinarily the wheels

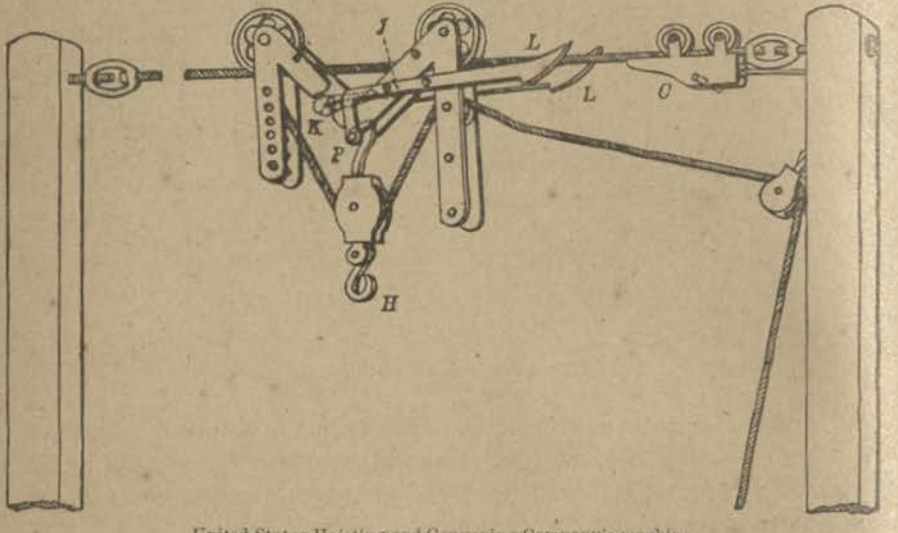
revolve in opposite directions, but the ratchets in the drill prevent this except in correspondence with the return movement of the handle (or shafts). Besides its continuous motion its principal advantages are to be found in its compactness and the physical relief found in practice, by varying the direction of the effort.

James L. Hall, Old Colony Rivet Works, New York.

Price: 12-inch handle, $13.50; 18-inch handle, $19.

UNITED STATES HOISTING AND CONVEYING COMPANY'S MACHINE.

This is formed of a double, M-shaped frame, running by means of rollers upon an overhead rope. The load is suspended by a hook, H, in a movable pulley from a transverse pin, P, joining the ends of a double lever, L L. This lever is pivoted to the frame J; further out is a brace bolt, B. The hook is permitted a limited oscillation in the

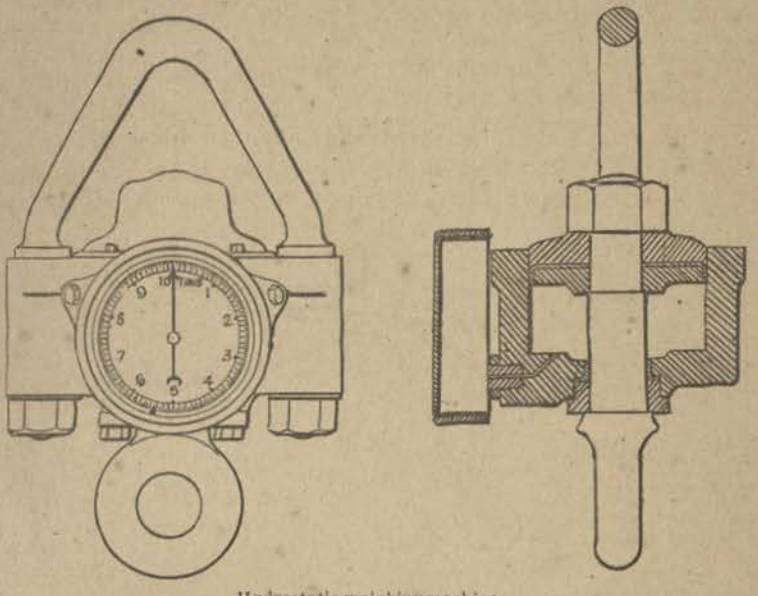


United States Hoisting and Conveying Company's machine.

pulley frame. The hook is released from the pin by simply checking the run of the hoisting rope; this raises the hook from the pin, and lifts the pawl K, which falls back over the pin, preventing the hook from catching as it comes down. To engage the hook again it is necessary to raise it from beneath the pin by the hoisting rope. In rising it lifts the pawl, and being stopped at the proper moment can be lowered to take hold. When the load is off, the barbed ends of the levers drop ready to engage with the pin in the movable car C. One of these cars is put at each end of the line if necessary, the levers being doubled when two are used. When the load is on, the weight lifts the notches off the pin in the car and allows the load to travel. Such an arrangement might be useful with the modification of the groosokat or Russian traveling crane proposed. It might easily be extemporized from wood, if unloading stores from barges in the field, &c. The machine is said to be extensively

used by the Manhattan Gas Light Company, New York. Running on a rope span of 200 feet, it raises coal 25 feet, and stores it at the rate of 300 tons per day of 10 hours, with one man per machine.

UNITED STATES HOISTING AND CONVEYING COMPANY'S HYDROSTATIC WEIGHING MACHINE.



Hydrostatic weighing machine.

This depends upon registering the compression of a fluid by means of a dial gauge. The fluid used is castor-oil, probably on account of its elastic and lubricating qualities. The piston movement is so slight that no cap is required for the cylinder.

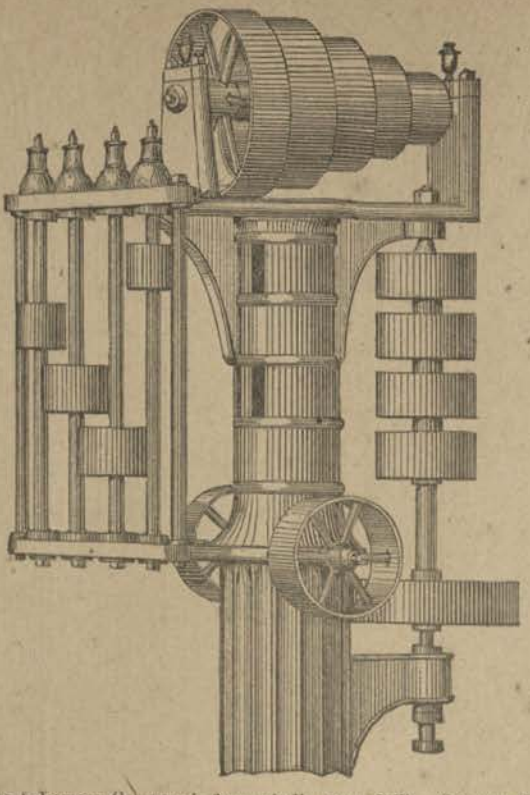
The machine is intended to be used in connection with the machine above described. It is made for from 1 ton to 100 tons, indicating variations of from 5 to 200 pounds, respectively. It costs from $100 to $650, according to size.

JONES & LAMSON COMPANY FOUR-SPINDLE PRESS DRILL.

The peculiarity consists in the neat and compact arrangement of the spindle belting. The cone pulley above is conveniently placed for belting to counter shafting. The spindle belting where necessary passes through slots in the post. Three different sizes of spindle pulleys allow variety in speed for holes of varying size.

Price, $325.

Made by the Jones & Lamson Company, Windsor, Vt.



Jones & Lamson Company's four-spindle press drill. (See page 909.)

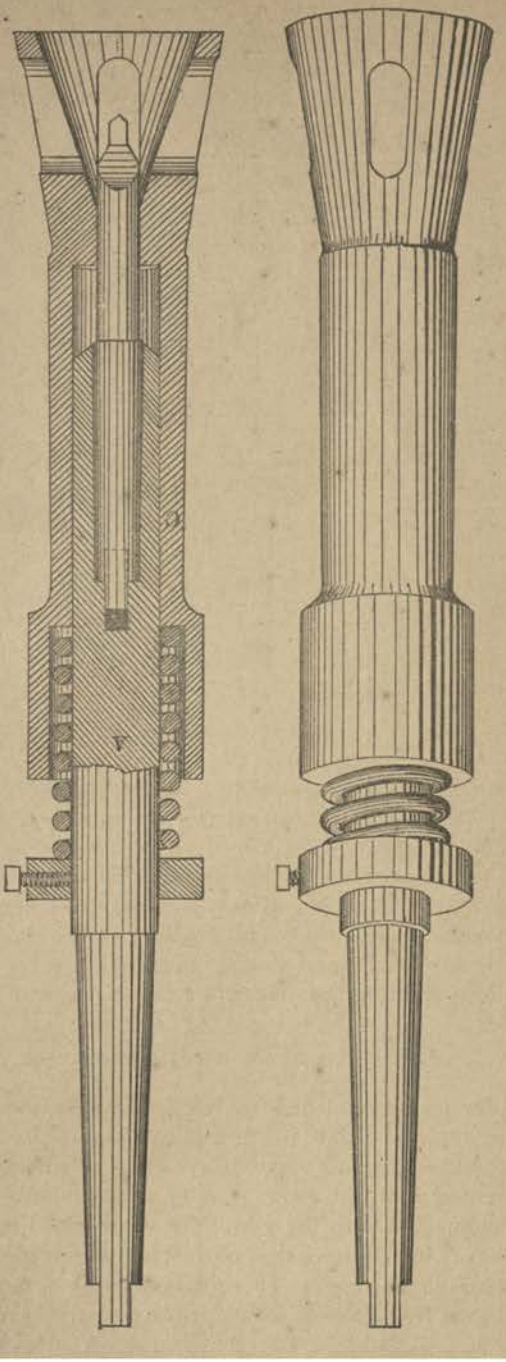
KELLY AND LUDWIG'S CENTERING ATTACHMENT.

This consists essentially of a bit provided with an ordinary flat drilling point, which is enlarged in rear to form a proper conical countersink, for use in finding and drilling centers in round or square iron in preparing it for the turning lathe. The drill stock A is surrounded by a sliding sleeve, C, the outer end of which is funnel-shaped and serves to guide the rough piece to the center drill. The sleeve is kept pressed out by a spiral spring surrounding the drill stock. The funnel is slotted to allow of oiling the drill and to allow chips to escape.

Cost, $6.50.

KELLY AND LUDWIG'S GEAR CUTTER.

This machine is distinguished by its compactness and the absence of the large and expensive dial plate usually employed. Its peculiarity consists in the use of a pair of carefully-cut gear wheels, the larger of which is mounted upon the same spindle as the blank to be cut. On the spindle connected with the smaller or spur wheel may be affixed a ratchet wheel of any desired size, corresponding to the number of divisions of the circle required. This ratchet wheel is moved by a pawl, which may be set by means of an eccentric collar on the spindle, so as



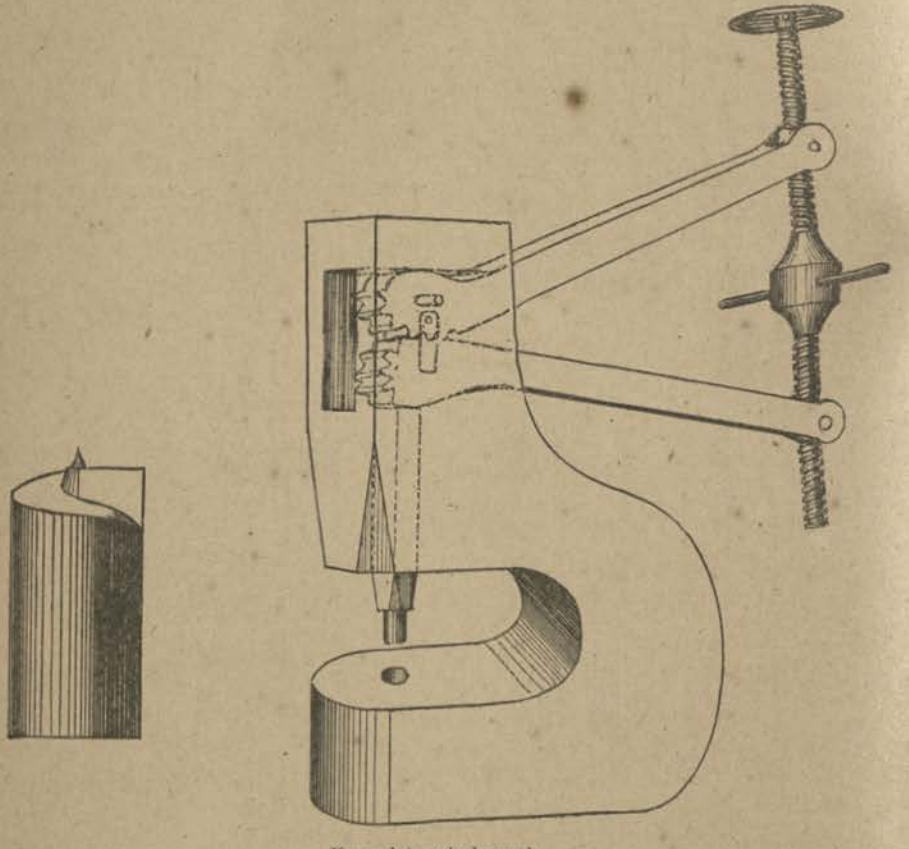
Kelly and Ludwig's centering attachment.

only to seize a certain number of teeth at each revolution. By moving this pawl once after every cut, the blank is turned to the desired extent. A table comes with the machine, which gives the number of the ratchet wheel to use for a given number of teeth, and the number of teeth in the ratchet wheel which the pawl should be set to.

The machine has a capacity of 22 inches diameter by 7 inches face; it will cut every number to 100 and even numbers to 186. It cuts spur, bevel, and worm wheels, and gears of six teeth to inch diameter. It occupies a space 24 by 32 inches and costs $225.

KENNEDY'S SPIRAL PUNCH AND PRESS.

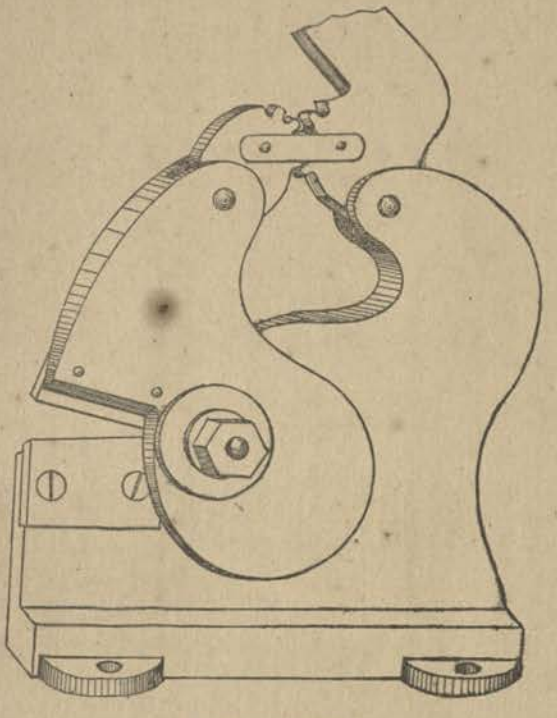
The end of the punch is spirally formed so as to facilitate its entrance into the material. The strain is applied to the punch by means of a



Kennedy's spiral punch.

kind of cogged toggle-joint forming, as it were, a succession of toggles. For great pressures the power is applied by means of a right and left hand screw traversing the outer end of the two working levers. With such an apparatus as shown in the sketch, it is said that three ¾-inch holes can be punched in ½-inch iron per minute. The pins do not re-

ceive the thrust from the toggles; this is taken up on the body of the machine itself. The pins and side strap merely serve to confine the parts. By practical application the *shearing* effect of this punch was very perceptible; a flat punch in the same machine seemed to *break* through, while the cut with this was much more even and gradual. It is said to distort the material punched less than the flat punch, and to be more than twice as effective as the ordinary beveled punch, besides not causing the work to slide.



Kennedy's shears.

The cost of a shearing machine of the kind shown in sketch, cutting ¼-inch sheet metal, is $55, and of the kind with the double-power screw, $85.

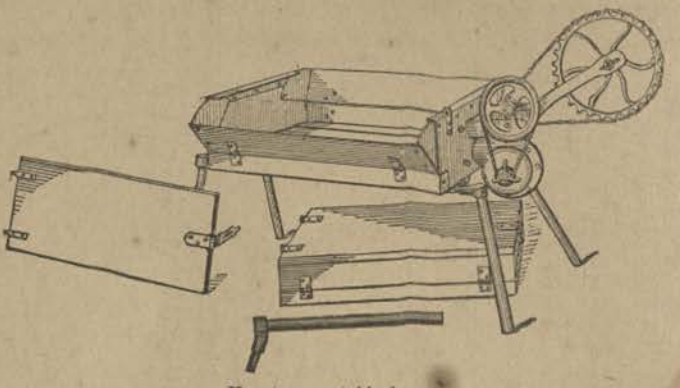
Address D. L. Kennedy, No. 3 Vesey street, New York.

KEYSTONE PORTABLE FORGE.

The pattern shown, called the miners' forge, is very compact and convenient. It measures 15 by 22 by 6 inches, weighs 70 pounds, and costs $45. The fan is run with a drive-chain, which engages with cogs on the head pulley and the intermediate pulley. The fan itself is driven by a twisted leather belt. The mouth of the blower terminates in a boss-shaped tuyere inside the box. The entire blast apparatus can be unhooked from the side of the box for storage. The side sketch shows how the frame of the blast apparatus is arranged for this purpose.

The drive-wheel runs in an adjustable bearing for taking up the slack of the chain. The legs are tubular and provided with fixed heads sliding in grooved studs beneath the body of the forge.

The forge is made by the Keystone Portable Forge Company, 120 Exchange Place, Philadelphia, Pa.



Keystone portable forge.

KLEIN'S ECCENTRIC PISTON ENGINE.

The principle of this engine, which belongs to the general class of rotary engines, may perhaps be best understood by first considering the skeleton sketches. S (Fig. 1) represents the horizontal cylinder of a height equal to one-third of its diameter, P the piston, cylindrical in form, and revolving on a crank, C, about the main shaft A. The face of P is covered by a plate large enough to close the mouth of the cylinder completely in all positions of the piston. H is a fixed hub so formed as always to have some point in contact with P during its rotation. I and E are the induction and exhaust ports respectively. They are separated by the fence F entering a slit in the cylindrical portion of piston.

The action of the engine is as follows: Suppose the steam entering through I, as in Fig 1. The piston touches the walls of the cylinder and hub at the points 1 and 2, and prevents the steam from escaping. It consequently fills the shaded portion inside completely, and pressing against the left semicircle of P, its resultant being normal to the surface, passes through the center of P at right angles to the crank. This causes the piston to advance, as shown by the arrow, to the second quarter of its revolution. Here the steam enters on both sides of the ring of the piston, balancing itself against the two sides of the upper half, but being stopped at the points 1 and 2 presses against the lower semicircle with the same result as before.

In the third quadrant the points 1, 2 prevent the escape of the steam which we have just considered, which is now carried around within the piston as inert steam, by the pressure resulting from the entrance of a

fresh supply, through I. The steam now presses upon the *outside* of the piston. Its resultant is, as before, at right angles to the crank.

In the fourth quadrant the exhaust has just begun, liberating the inert steam just inclosed within the walls of the piston, the effective pressure resulting as before. It will be seen, therefore, that the piston *rolls* around upon both the cylinder and the hub, touching the latter at all points of its exterior surface in succession, and the former at all

Fig. 1.

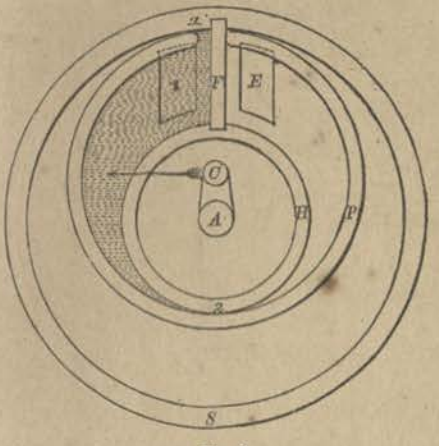


Fig. 2.

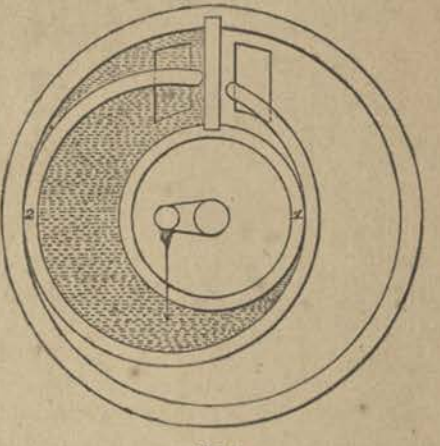


Fig. 3.

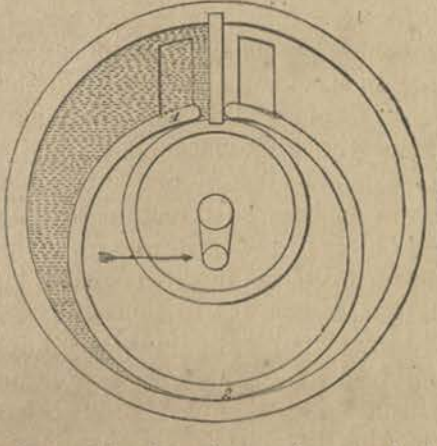
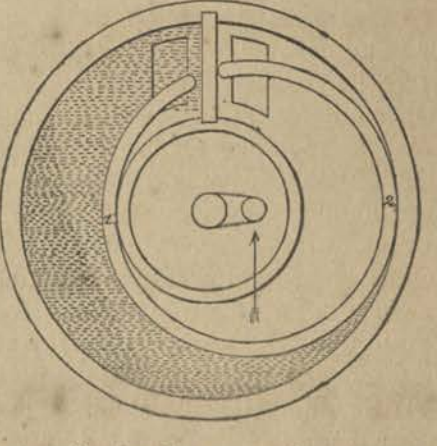


Fig. 4.



points of its interior surface, and thus acting as its own valve system, and bringing the effective pressure always at right angles to the crank.

The engine can be reversed by simply changing the direction of the incoming steam. In practice the engine is arranged as seen in Fig. 5. The piston plate is perforated and inclosed on the other side by a casing like that of the cylinder. This is to equalize the steam pressure and prevent excessive friction. This casing is used as a cylinder also, steam being admitted simultaneously through the perforations in the piston and the port I.

The plate covering P, and extending over C, is necessarily eccentric with regard to its axis of rotation. It is therefore balanced by being weighted on the opposite side of the center. Various points of detail are also involved in regard to the wear of the piston crank-pin boxes. The outside section of the standing frame meets the cylinder section in a helical joint, X Y. This prevents the wear on the bearings of the piston to be taken up by means of the pinion K, by which the two sections can be screwed together. The crank-pin bearing is arranged

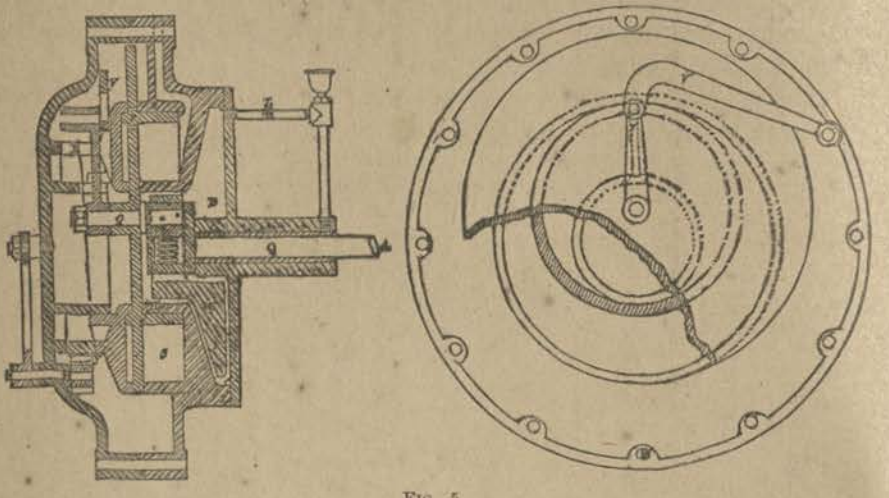


FIG. 5.

as follows: Supposing the pin were fastened permanently to the crank, and with a loose bearing in the piston, it would wear itself off on one side and make its bearing larger all the time, and in practice would rattle and jump as the bearing changed. But suppose it fastened to the piston with a loose bearing in the crank-box, as it is actually arranged in practice. In this case its bearing is constant on the crank-box, so that it wears a slim, cylindrical hole there, always fitting its own surface, which is reduced regularly by its own rotation in this bearing.

Returing to the skeleton sketches, Figs. 1 to 4, it will be seen that, arranged as it is there shown, it would be difficult to maintain the exact position of the sides of the slit in the piston with reference to the partition, and that if made to slide upon this slit, the lubrication of this bearing would be difficult. In practice this difficulty is met as follows: A connecting-rod *r*, Fig. 5, is secured to the crank-pin C in the same way as the piston is secured. The upper end of this rod is jointed to a vibrating lever V, the other end of which is jointed to one of the bolts binding the two sections of the frame together. This lever is so set as to limit the lateral motion of the piston so that the sides of the slit will just clear the partition.

The lubrication of the long bearing Q is as follows: The counterpoise weight W also acts as the vane of a centrifugal pump, and taking the

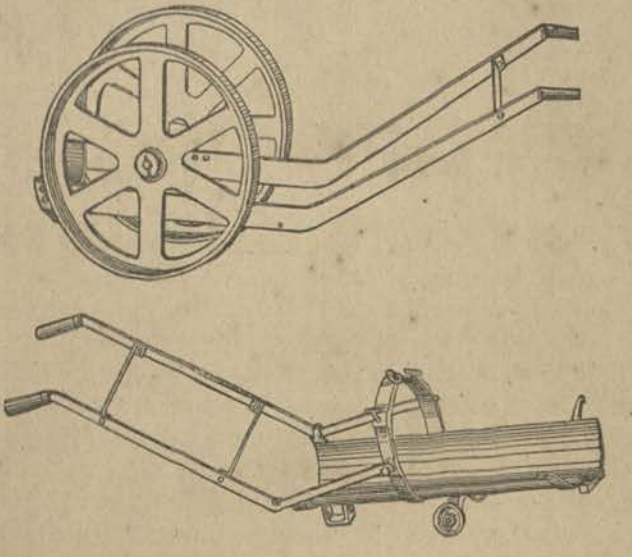
oil which leaks in from the cup, through the bearing, forces it out again through the tube L, and thus uses it over and over again. The crank-pin box is pierced with holes, through which the emulsion of grease and water, with which the space F eventually becomes lined, reaches the bearing of the crank-pin.

The double spring beneath the crank-box serves to bring the piston always to its bearings even when no steam is on. One of these engines is constantly in operation running a heavy set of wall-paper printing machinery in Machinery Hall. It occupies a floor space of about 24 by 30 inches, and stands 30 inches high. It has been run without difficulty during the Exhibition.

Charles C. Klein, 2302 Parrish street, Philadelphia. Cost, 3 horse-power, $200; 6 horse-power, $275.

KRUPP'S 35.5 CENTIMETER GUN SHOT-BARROWS.

Sketches of shot-barrows used with the Krupp 35.5^{cm} guns are here given, and do not require any special description.



LANGEN & OTTIS GAS-ENGINE.

A fixed vertical cylinder open at the top contains a piston, on one side of the rod of which a straight rack is cut. This rack gears into a toothed pinion on the same shaft as the fly-wheel. This pinion is provided with a friction bearing on the shaft, which causes it to revolve with the shaft in one direction only, this direction corresponding with the *downward* movement of the piston. Gas and air mixed in such proportions as to give a mild explosive compound are admitted under the piston. The compound is ignited by a stationary gas jet; it explodes and the explosion drives the piston freely upwards, merely overcoming its weight

and friction and displacing the air above it in the cylinder. The ignited gases increasing in volume lose their heat; their pressure is reduced, and when the piston-head has reached the top of the cylinder a partial vacuum is formed beneath it. Then the pressure of the atmosphere makes the piston descend, turning the fly-wheel as it goes. This descent is made *steadily*, as it depends upon the nearly uniform pressure of the air. The rotation of the fly-wheel is therefore much more uniform than if produced by the fluctuating pressure of the gas alone. When the speed of the fly-wheel is notably diminished, the governor admits a measured quantity of gas into the pump, by which it is forced into the cylinder. Thus, when running free, an engine will run several seconds without pumping, but when working the explosions are almost continuous.

The consumption of gas amounts to 26.5 cubic feet of common gas = 0.2 gallon of coal-oil per effective horse-power per hour. The following sizes are made; ¼, ½, 1, 2, 3, effective horse-power, costing $290, $500, and $700 for ¼, 1, and 2 horse-power, respectively.

Schleicher Bros., agents, No. 119 North Fourth street, Philadelphia.

MAIN'S MILLING ATTACHMENT FOR LATHES.

The face-plate is taken off, and a gear-wheel with a center screwed on in its place. When in use this engages with another gear-wheel,

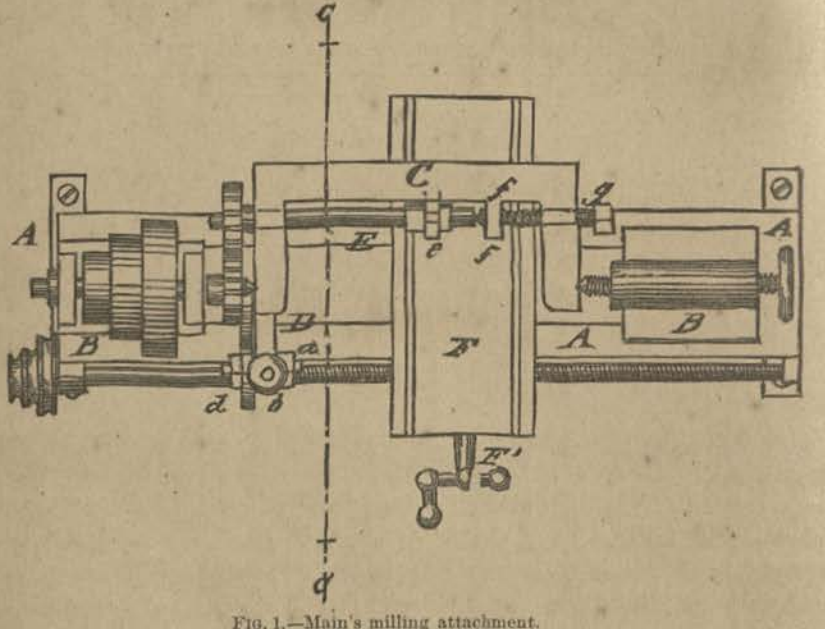


FIG. 1.—Main's milling attachment.

on the end of the rectangular frame C, pivoted on the two centers of the lathe. This last gear-wheel is on the shaft E, on which the mill *e*, is placed. The other end of the shaft rests on the center screw *g*, pass-

ing through the end of the frame and the stud *f*, *f'*. The bed F can be given a transverse motion by hand or a longitudinal one by the feed-screw. In the lathe under consideration it can be set obliquely to the mill-spindle. Fig. 2 shows an arrangement by which the center frame can be turned on the lathe centers around the work. Two nuts, *a* and

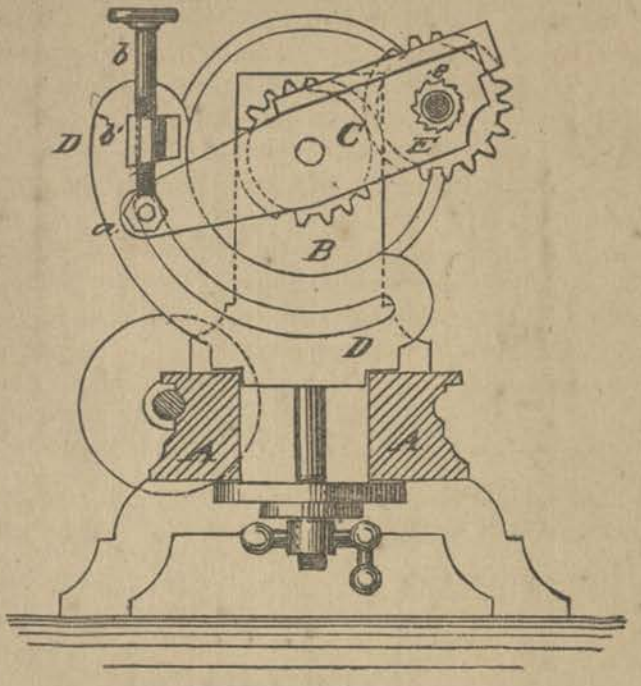


FIG. 2.—Main's milling attachment.

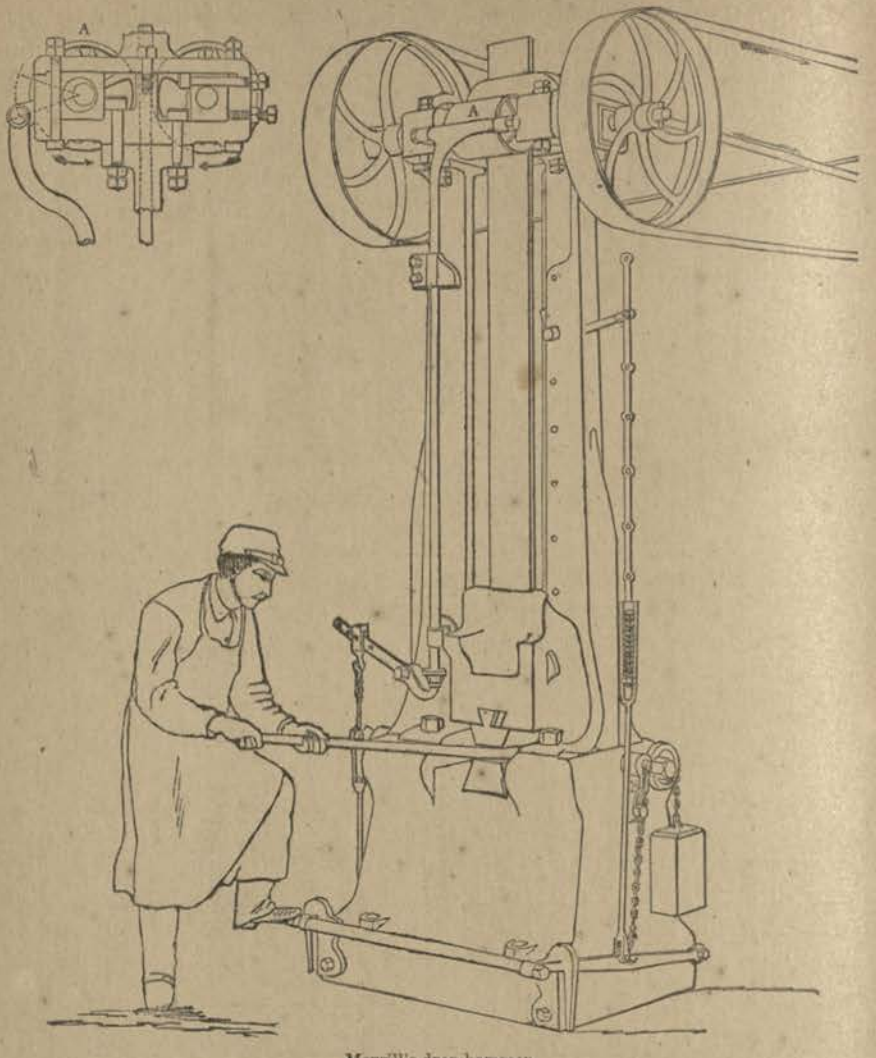
b, in the curved slot, permit the mill to be raised to any height desired. By clamping the nut at *b* and loosening *a* the mill can be fed in a circular direction by turning the hand-screw *b*. The clamp beneath the frame A holds the attachment upon the slides.

William Main, jr., 1909 Pine street, Philadelphia.

MERRILL'S DROP-HAMMER.

This belongs to the class of drop-hammers in which an iron hammer head is raised by a vertical board passing between two friction rollers, revolving in opposite directions. Ordinarily these friction rollers are driven by gearing. In the Merrill hammer the rolls A A are independent, each having its separate shaft and separate pully. These shafts are horizontal, on opposite sides of the ways, the rear one being allowed a slight motion toward and from the other at the top. The pulleys, are on opposite ends of the shafts. One of them, the rear pulley, being run by a crossed belt, the required direction is given to the revolution of the rolls. The shaft of the rear pulley revolves

within an eccentric collar, connected by a rod with a treadle below. The weight of this rod tends to throw the rear shaft inward and

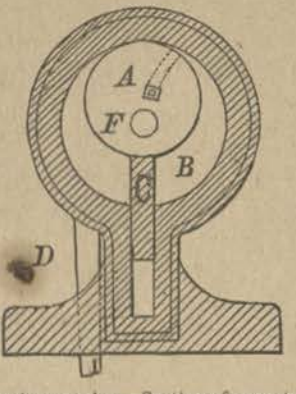


Merrill's drop-hammer.

carry the roller toward the board. As soon as the roller grips the board it raises it to the trip on the right-hand way. By pressing the treadle with the foot the connecting rod rises to the position shown in dotted line, small figure; in consequence the eccentric retreats, carrying the roller away from the board, and allowing the hammer to drop of its own weight. By the same motion the trip is withdrawn. The former method of releasing the hammer comes into play in working with a quick variable blow. The trip is used where a fixed blow is required.

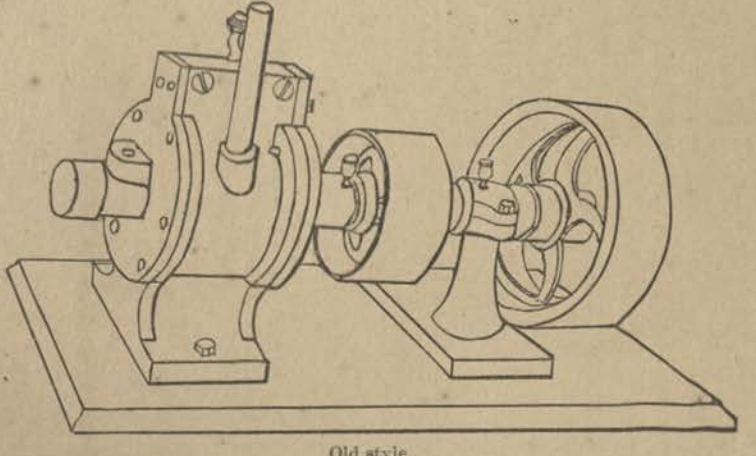
MOODY ROTARY ENGINE.

The steam enters through the cylinder head by a circular port of greater or less extent depending on the cut-off. It passes through the port D, and issues through the steam passage shown in dotted lines into the space B. Here the pressure is exerted against the side of B,



Moody rotary engine.—Section of new style.

from the sliding abutment C upward. Part of the pressure is balanced between the wall of the cylinder and the side of the abutment. The effective part of it turns A around the fixed shaft F, with a crank leverage equal to the distance between the center of A and that of the shaft.



Old style.

As it revolves it presses the waste steam before it out of the exhaust E. The abutment is loose, merely sliding up and down in its groove. It is pressed up against the piston by steam, which enters through a small port in the cylinder head and runs downward beneath the abutment. This steam is cut off when the piston has passed the high point, and the abutment allowed to fall of its own weight. The exhaust port is made very large to avoid back pressure.

The engine is very compact. Its cost is for ½, 1, and 2 horse-power, $30, $60, and $100, respectively. A perspective view is given showing the parts reversed as it was formerly made. In this case the contact between the sliding abutment and the piston is by the weight of C.

Jeffery Machine Works, 253 South Canal street, Chicago.

NICHOLS ACID PUMP AND SIPHON.

This useful machine is too simple to require a drawing. It consists of a siphon, the short leg of which enters say a carboy to the required depth. On the short leg near the bed is formed an enlarged chamber, into which both legs of the siphon screw. At its junction with the lower leg is a lifting valve, closing the connection from above. Connected with the chamber is a hollow rubber exhauster, like that used in the Davidson syringe. By using this the acid or other fluid fills the siphon and keeps running as long as desired. The apparatus is fitted with a stand by which it can be stood upon the top of the carboy.

Price, $5 and $10.

Nichols, Harris & Walker, New London, Conn.

NICHOLSON FILE COMPANY.

The Nicholson File Company, Providence, R. I., exhibit files made with their "increment" cut, by which the chisel makes a fine cut at each end of the file, increasing in force at the middle. Also at every few strokes the cut is deepened or made shallower than the average, so as to make the entire file partake of the irregularity of hand-made work. This is for single cut files. For double cut files the crossing of these ridges of different widths causes the points to lie "off the line," and so prevents the extremely uniform wear and consequently short life common to machine made files. In their half-round files, the cuts are irregularly disposed so that when looked at by shade they show a spiral arrangement.

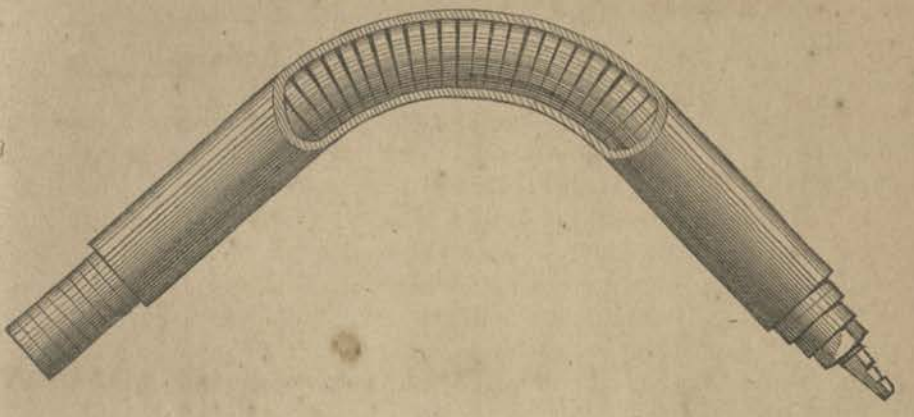
OHL & HANSCHILD PLANER.

The peculiarity of this planer consists in the use of two horizontal eccentric gears beneath the slide: one on a vertical shaft being connected with the driving apparatus; the other on a parallel axis transmits the power by means of an adjustable connecting rod, one end of which is fastened to the eccentric and the other to the slide. The use of the eccentric gives the quick return stroke, the length of which is regulated by the adjustment above mentioned.

ORAM'S PATENT MANDREL FOR BENDING PIPE.

This consists of a cylindrical spiral coil of square steel wire, made a trifle smaller than the bore of the pipe in which it is to be inserted. When in place it supports the pipe, so that it can be bent without changing its cross-section at the point of curvature, or without heating

it, as is customary when lead or rosin is used. To remove the mandrel after bending, it is turned against the direction of the helix, by a socket brace fitting over a square tenon on the end of the mandrel. This reduces its diameter appreciably, and allows it to be withdrawn.



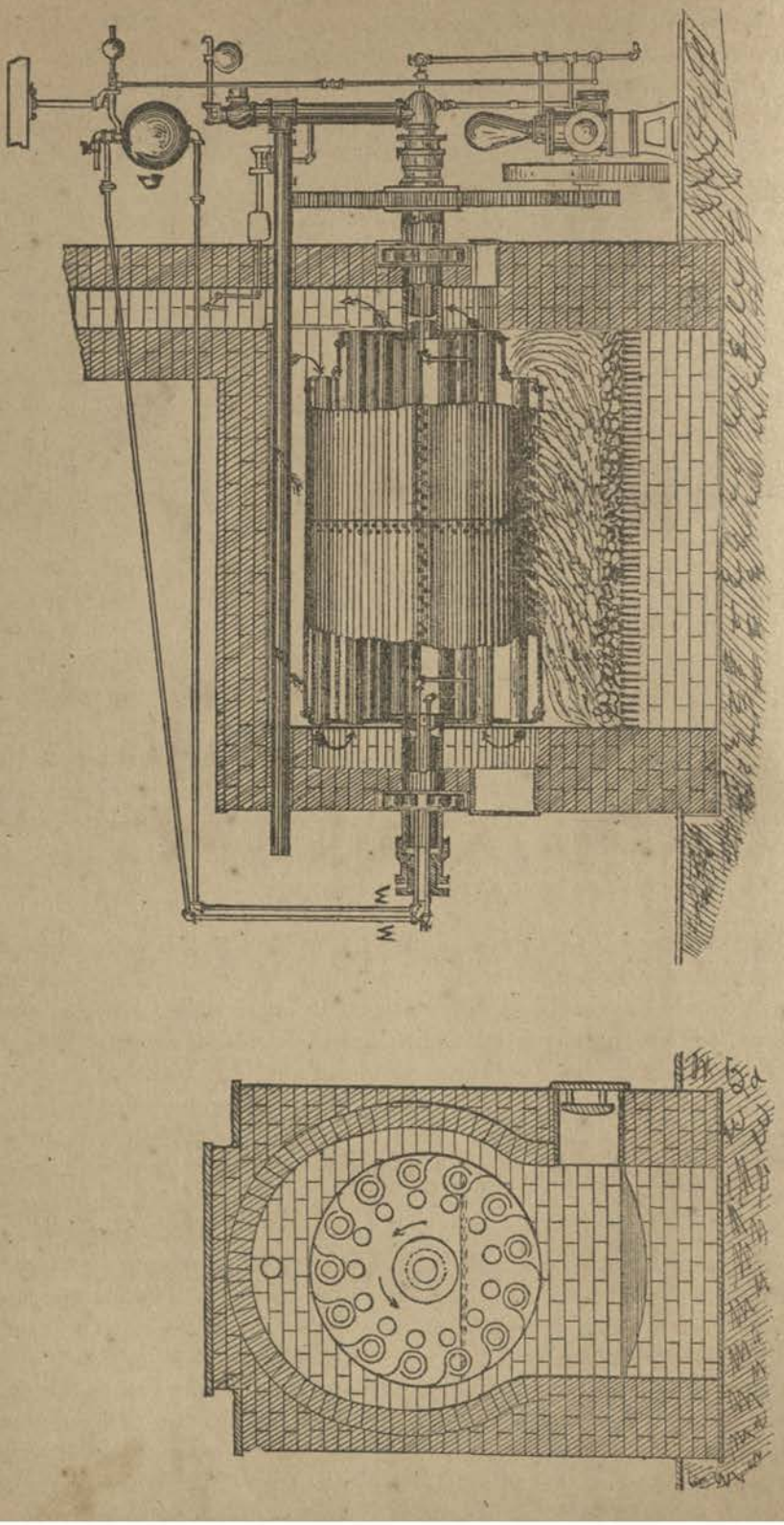
Oram's mandrel for bending pipe.

For long pipe the mandrel can be slipped into the bending point, and withdrawn by a long rod. M. L. Oram, No. 702 Chestnut street, Philadelphia.

THE PIERCE ROTARY BOILER.

This consists of a cylindrical shell revolving horizontally on its own axis, and containing two concentric rows of tubes. In the revolution of the boiler the outer row of tubes dips into the water and by means of the scroll buckets or elevators surrounding them, carry around a portion of the water with them, generating steam from their own heated surface as well as from the drenched surface of the heated boiler shell. By an automatic device the water level is kept fixed just covering the few lowest members of the inner row of tubes. The upper ones, consequently dry or superheat the steam formed by the outer row, besides generating a certain quantity of steam on their own account. The boiler turns on friction rollers surrounding its trunnions and incased in a cylindrical shell. Motive power is furnished by the steam pump, or otherwise. The revolutions are about one per minute.

The trunnions are hollow, water entering through one trunnion and steam escaping through the same one. The water regulator pipes pass through the other trunnion. The grate runs the whole length and width of the boiler, but may be restricted in extent by bricking it over if desired. The flame passes around the boiler above and below. The outer row of tubes is made shorter than the body of the boiler so as to produce an offset at the forward end. This allows the flame to enter through these tubes, and to pass through their entire length to the rear. Here it enters a circular chamber built in the brick-work and being prevented from escaping, on account of the contact of the rim of the boiler head



Pierce's rotary boiler.

with this brick-work, turns back through the inner row of tubes and eventually escapes through the chimney in front. The steam pipe turns back through the arch over the boiler to utilize the heat of the flame in superheating the steam. The boiler turns so easily that it may be started by hand. In three minutes, with wood fuel, steam will form, and in twenty minutes there will be 60 pounds pressure.

The advantages claimed for this boiler are the following, and mainly admitted in a report made by Prof. R. H. Thurston: (1.) Thorough stirring of the water liberating all steam which may have been generated, and preventing priming, furrowing, or incrustation; it evaporates a cubic foot of water per hour, with but 8 feet of heating surface. (2.) Covering all parts of the boiler shell with both fire and water, preventing overheating or unequal expansion and contraction. (3.) Freedom from contact with masonry, thus avoiding external corrosion. (4.) Facility of inspection and repair.

The cost is said not to be greater than for the other boilers of the same size.

In Professor Thurston's experiments he reports evaporating 10¼ pounds of water from 212° F., with 1 pound of coal, giving steam with only 2.5 per cent. of water of condensation.

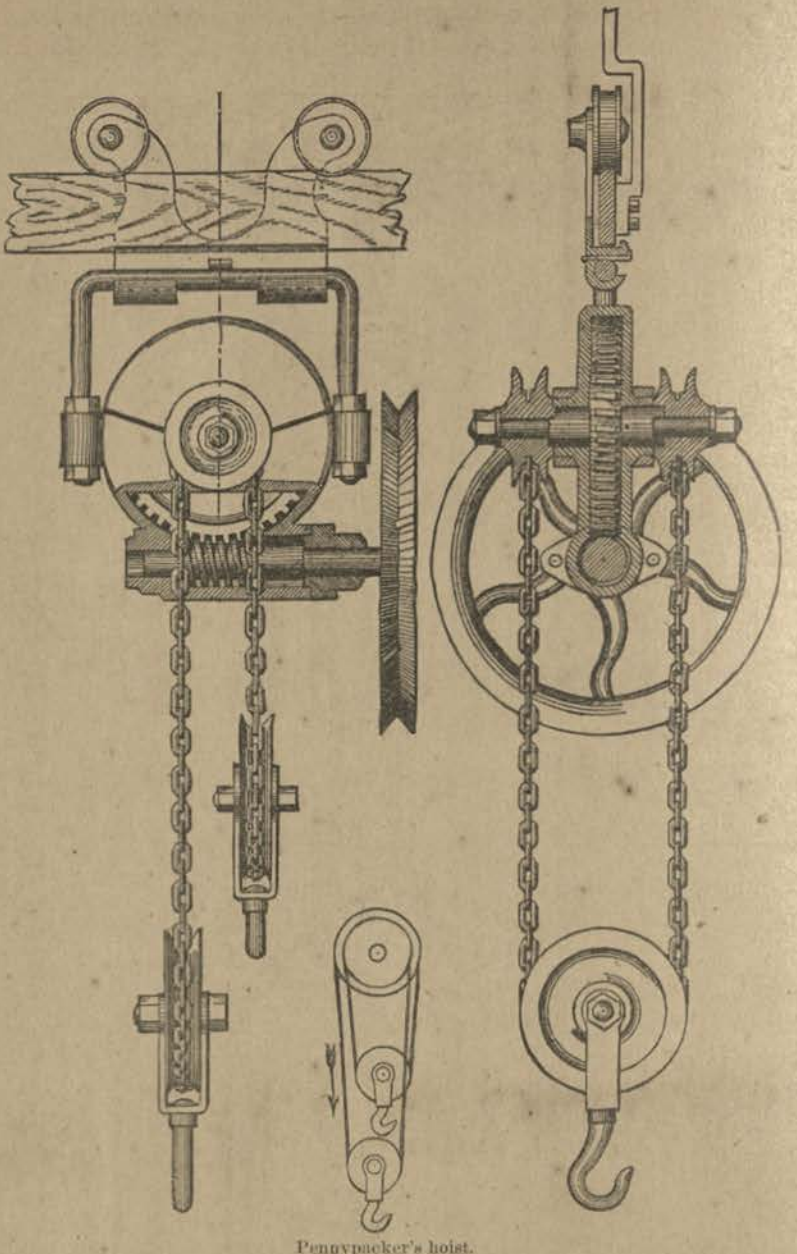
The automatic water regulator acts as follows: If the water rises to cover both the pipes M M to the left, the pressure of the steam will drive the water up through the pipes into the large hollow ball G. This will then overbalance the counterpoise weight and drop, shutting off the water by the rod connected with the pump. The normal position of this balance is that permitting the water to flow slowly into the boiler.

PENNYPACKER'S HOIST.

The power is applied by means of a light chain to the socket wheel. This turns a worm gear, upon the hubs of the wheel of which are fastened, by means of clutches and a clamp bolt, small socket wheels, over which the lifting chain passes. The chain is made double to make it more convenient to handle than a single chain of the same strength, and to allow of continuous hoisting, a hook being fastened at each end to balance the strain on the axle. The screw revolves in a chamber full of oil. It will sustain its load at any desired point, but will lower rapidly when started. One man can lift 4,000 pounds with it. One of the principal advantages of this hoist is found in the oil box, within which the worm gear runs. This reduces the friction to such an extent, that by merely giving a good pull to the hand chain, its own momentum and that of the gearing has been known to lift a locomotive frame weighing about one ton.

A modification of this hoist has recently been made, in which, as shown in the drawing, the two side pulleys are of slightly different diameter. By crossing the chain, as shown in the small sketch, so that it will pass down from the larger pulley, under its movable pulley, up and over the

smaller pulley *on the other side of the pulley*, then down and under its movable pulley and up again over the larger pulley to where it began,



Pennypacker's hoist.

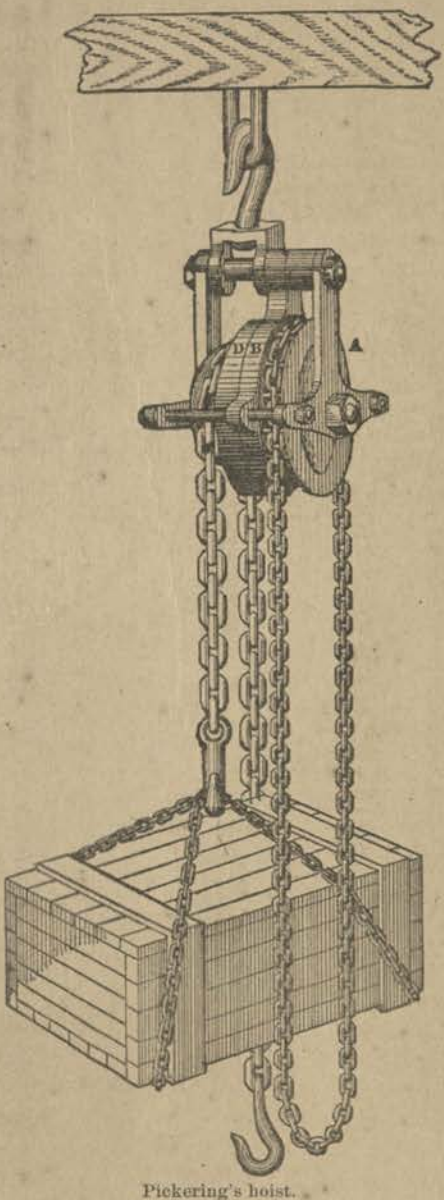
a differential lift is thus obtained, the weight being raised in proportion to the difference in diameter of the two pulleys.

The overhead truck is conveniently arranged for passing the points of suspension.

The apparatus is made at the Baldwin Locomotive Works, Philadelphia; price, $75.

PICKERING'S HOIST.

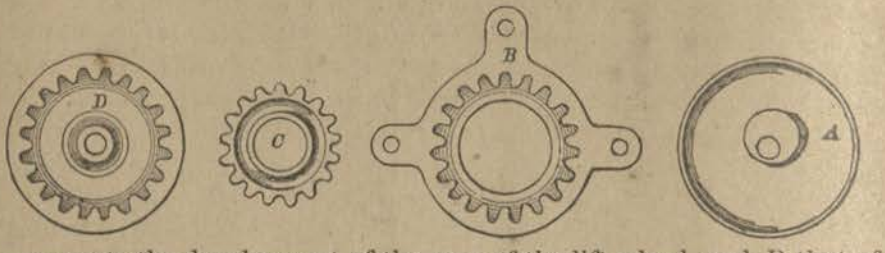
This block presents a case of differential gearing arranged in the following manner: Upon the eccentric hub in the hand chain wheel A revolves a pinion, C, which passes through the opening in the side of the



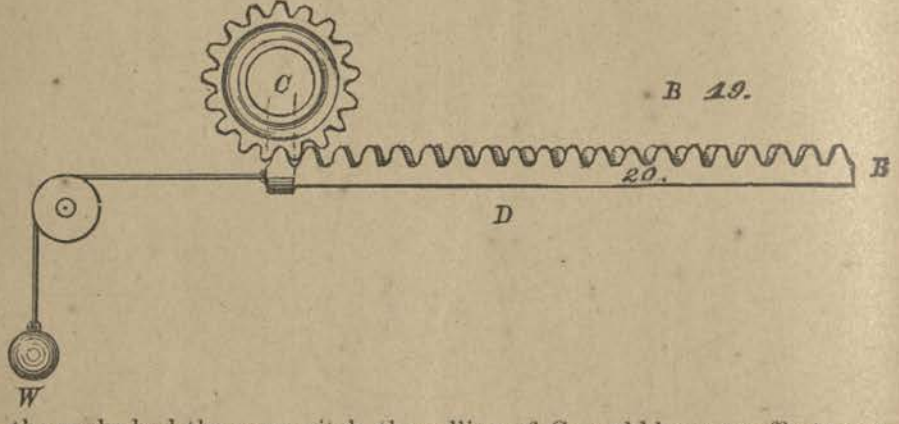
Pickering's hoist.

fixed wheel B and engages both into the fixed annular wheel formed on its inner surface, and into the internal gear inside the large part of the lifting chain wheel D. The fixed wheel, or rack, has 19 teeth, the lifting chain wheel has 20 teeth, and consequently at each revolution of the pin-

ion one tooth is gained upon the lifting wheel, giving it a slow but powerful motion of rotation. The lifting chain is kept from slipping by engaging with link socket formed on the concave edge of a small hub upon the outside of the lifting chain wheel. The lifting wheel is locked against the strain from the weight, and kept from turning back by the peculiar arrangement of the gearing. This is difficult to explain, but may be understood from the following exaggerated figure, in which D



represents the development of the gear of the lift wheel, and B that of the fixed rack behind it; C is the pinion. As the development of the racks precludes the idea of revolution of the pinion about any exterior axis, it will be sufficient to consider it as constrained to roll along A and B, engaging with both of them at once; B being fixed, and A free to slide in the direction of its own length. The pinion's motion of translation will then correspond with its actual revolution about the common axis in practice; its rotary motion will be repeated as in practice. If



the racks had the same pitch, the rolling of C would have no effect upon their relative positions, but D has 20 and B only 19 teeth in equal lengths; consequently, in estimating from a coincident position, the teeth of D will lap those in rear by $\frac{1}{20}$, $\frac{2}{20}$, $\frac{3}{20}$, &c., of the space of D. The pinion C, consequently, forced to roll along B, also wedges in between the teeth of D, sliding it forward $\frac{1}{20}$ of the space at each tooth, or 1 tooth at each revolution.

The locking is as follows: Since the action of the racks upon the pinion, supposing them of equal pitch, can only result (friction apart) in rotating the pinion on its own axis, it will be safe to disregard the exterior axis of common rotation, and suppose the pinion in the figure to

be upon a fixed axis. Then suppose a weight, W, attached to A, as shown. The pinion will attempt to revolve, but its lower teeth on the right will bear against the fixed teeth of B, and block it, the only result of the motion being a strain tending to lift the pinion bodily upwards, from the racks. In practice this strain is received radially on the common axis, in dotted lines, corresponding to the stirrup shown in the sketch.

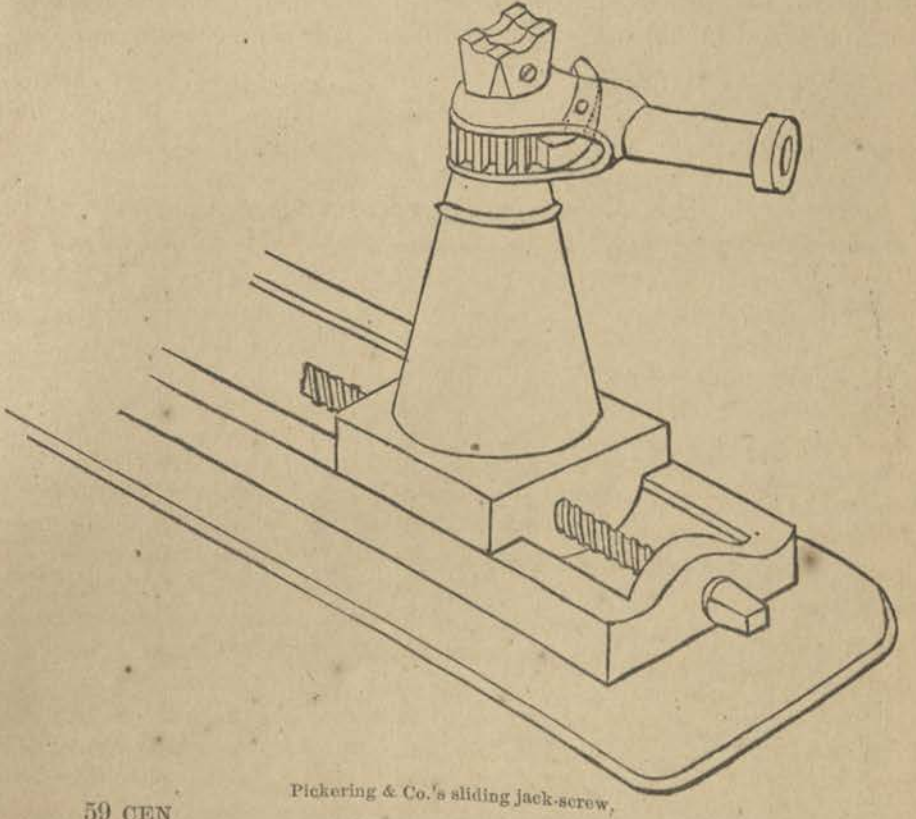
The following advantages are said to attend the use of the independent chains. The hand chain being independent of the lifting chain, although itself short, can be used for lifting weights from considerable heights, not accumulating under foot as the weight is raised. The lifting chain, having a hook at each end, can be used continuously in hoisting. The chain does not kink or jam in the upper block. It can be worked at any angle, enabling the workman to stand from under the load.

In one form shown, both ends of the lifting chain are fastened to a clevis hanging from the frame-bearing. The single hook is then attached to a movable pulley on the chain; the course of the latter being from the clevis down and under the movable pulley, over the limb of the lifting wheel, down in the slack loop, and up again to the clevis.

Prices: ¼ ton, $22.50; 1 ton, $30; 10 tons, $300.

J. PICKERING & CO.'S SLIDING JACK-SCREW.

The body of this jack-screw rests upon a bronze slide, the lower part



Pickering & Co.'s sliding jack-screw.

of which is traversed by a screw. Both ends of this screw are journaled in bearings formed in the ends of an open rectangular frame of cast steel upon which the bronze slide is transversed by the screw. Power is applied by a double-acting ratchet in the head of the lift-screw. One end of the bent pawl is engaged to raise the weight and the other end to lower it.

J. Pickering & Co., care Charles Merrett & Sons, 556 Grand street, New York.

PONSARD GAS-FURNACE.

This is essentially on the Martin-Siemens plan. It differs in being continuous, whereas the latter is intermittent in its action. A is the fire-room, &c.; B the hopper with its grate C on which the process of slow combustion is performed. The gases from the coal, in the form of carbonic oxide, pass through the flue D to the reverberatory combustion chamber E; after burning they depart through the smoke-flues F and H. On their way, while at a high heat, they pass through many *vertical* flues contrived in a pile of fire-brick G, and so bring the brick to a high temperature. In the meanwhile a current of air has been coming in from without through the air-chamber I, entering at a hole near the foot of the wall between G and I. This air, at first warmed by being surrounded on four sides with the products of the previous combustion of the gases, is still further heated by passing through zigzag *horizontal* passages contrived in the pile of fire-brick G, through which the heated gases have already passed downward. The air therefore issues at a high temperature through the flue L (passing on each side of the flue D), and enters the combustion chamber side by side with the gas through D with which it mixes ultimately and burns with great intensity. The process is thus indefinitely repeated. The ashes, &c., carried by the flame to G tend to fall through the vertical passages into the ash-flue H. Any accumulations are removed with pokers through holes in the wall dividing G and I. The small square holes seen in the courses of brick are to equalize the pressure between the down-flowing currents of hot gas. Valves, dampers, man-holes, &c., are provided where necessary.

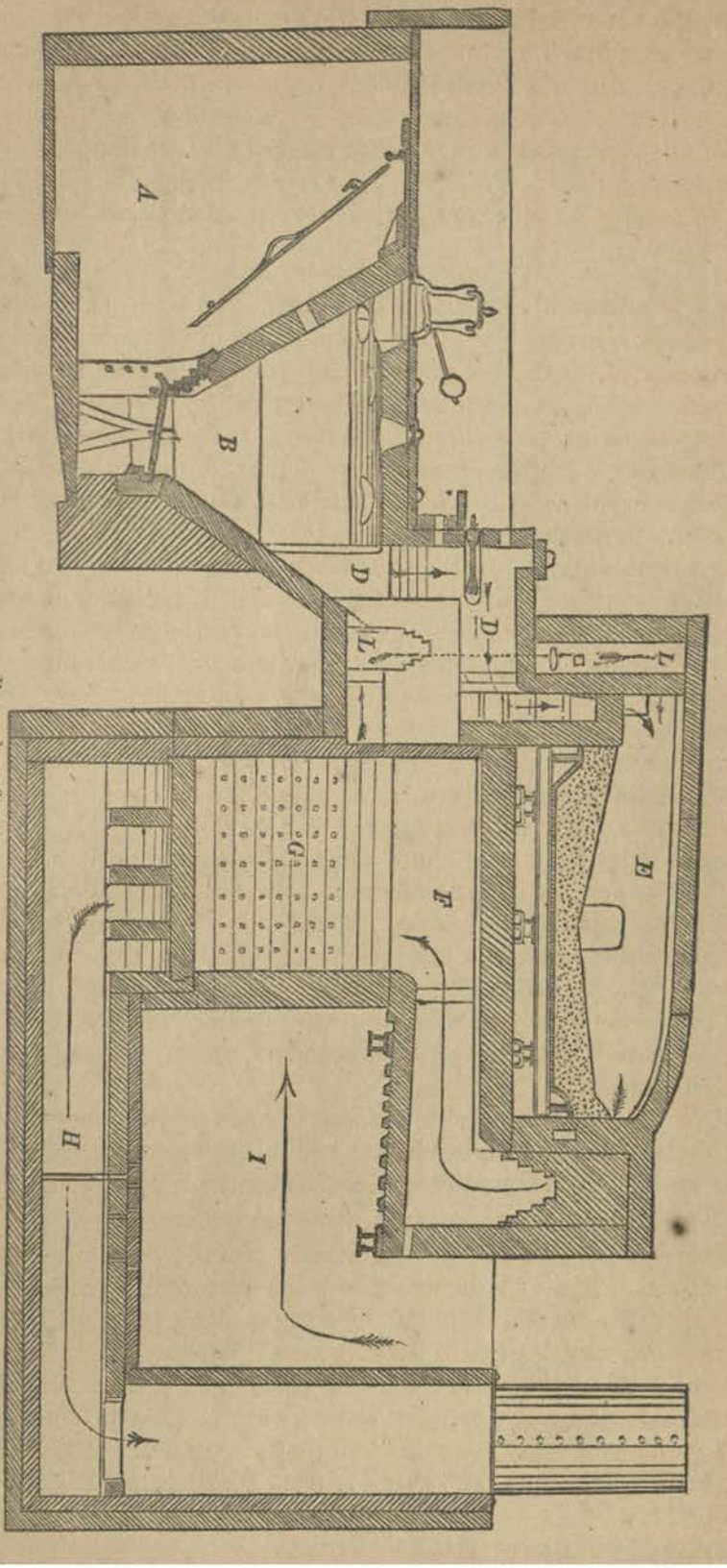
It is reported that such a furnace is built or is about to be built at the Sellers Works, Edgemore, near Philadelphia, to be used in connection with the rotary puddling furnace elsewhere described.

PRATT & WHITNEY'S SPRING WINDER.

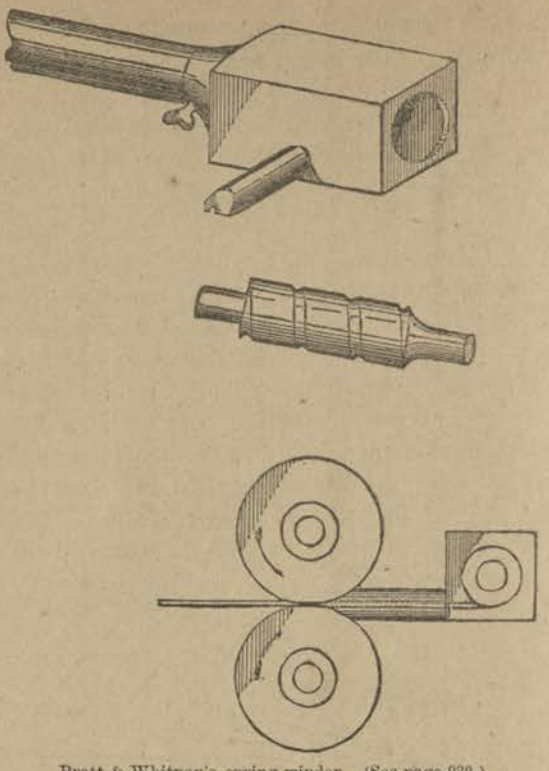
This consists of a pair of 3-inch rolls grooved to receive the wire to be wound. The wire being introduced into one of these grooves is forced by the revolution of the rolls into a small tube just large enough to take the wire, the end of it being beveled down so as to fit in between the rolls. This tube leads to a box parallel to the axis of the rolls, in which is fixed a short cylinder having cut upon its surface three turns of a spiral groove, of the pitch and depth required. A projecting spindle leads off the wire, and keeps it from kinking, &c.

Cost, $50.

Pratt & Whitney, Hartford, Conn.



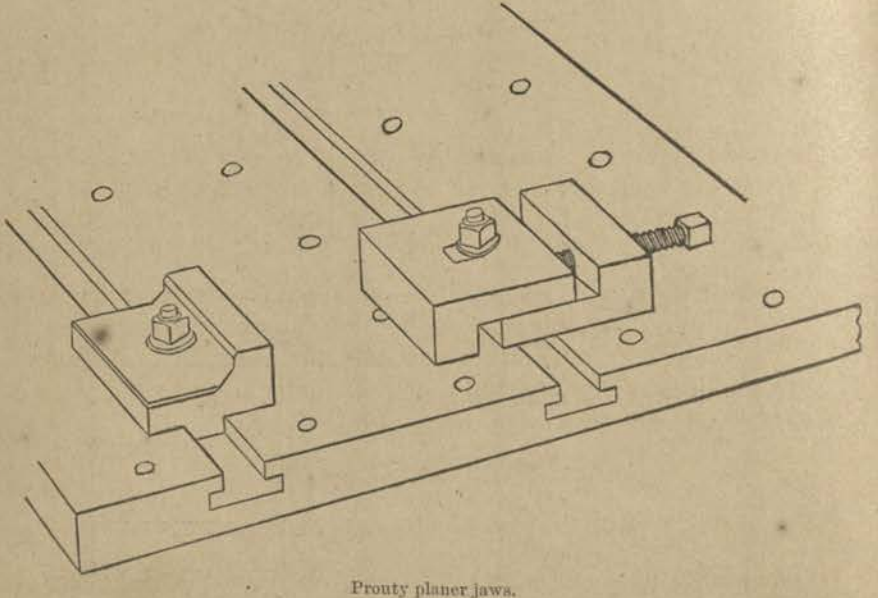
Ponsard gas-furnace.



Pratt & Whitney's spring winder. (See page 930.)

PROUTY PLANER JAWS.

These are intended for holding work upon the table of iron planers.



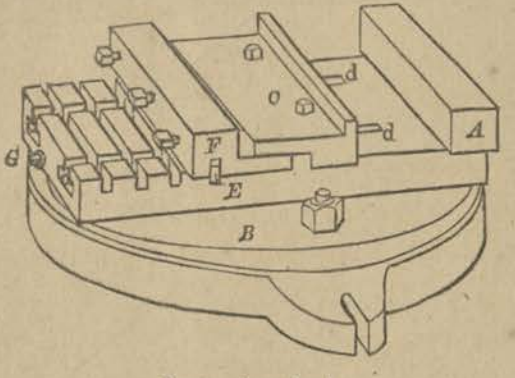
Prouty planer jaws.

They are held down by bolts with large heads sliding in T slots in the planer bed. The hole in the upper part of the jaw is elongated, and a traverse screw is provided for adjustments; $6 per set. One jaw and two angle irons each 4 inches long compose the set.

Manufactured by H. F. Prentice, Worcester, Mass.

PROUTY PLANER CHUCK.

This seems a convenient tool for holding work down to a planer bed. The portion A is solid with the bed, which turns at pleasure for oblique adjustments upon the service bed B. The abutment piece C can be set at pleasure along the bed, being held fast to it by two bolts with enlarged heads traveling in the longitudinal slots *d d*. The rear portion of the bed is scored across in parallel cuts to hold the key E, which secures the second abutment piece, F, from which by three longitudinal screws the piece C may be clamped against the work. The two abutment pieces are halved together to prevent tilting. The set screw G serves to clamp the bed A firmly to B, by a special frictional arrangement inside of B.



Prouty planer chuck.

Price with square base from 8-inch jaw to 18-inch jaw, $25 to $60; with round swivel base, 6-inch jaw to 12-inch jaw, $25 to $40.

REED'S TIRE HEATER.

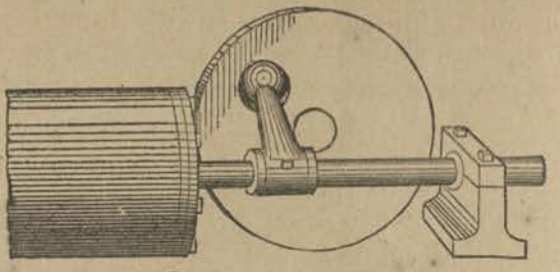
S. G. Reed, Boston, Mass., exhibits an apparatus for heating tires with gas. A circular table with radial slots in which move 8 sets of burners of 6 jets each. These may be brought near the tire simultaneously and give a very powerful heat. A similar arrangement is used for heating railroad locomotive tires *in situ*.

RUSSIAN VALVELESS ENGINE.

(See Wardwell valveless engine.)

The reciprocating semi-rotary motion is given to the piston by means of an arm keyed to the piston rod at right angles to its length. The ex-

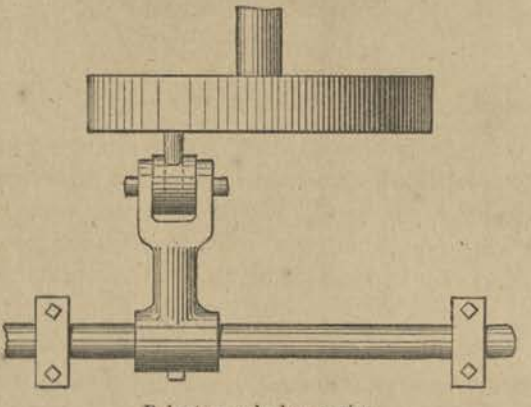
tremity of this arm passes freely through a sphere, embedded in the face, and near the edge of a solid iron wheel revolving in a vertical plane parallel to the axis of the piston. The reciprocating motion of the piston-



Russian valveless engine.

causes the wheel to revolve; this in turn causes the arm to play up and down, and thus to give the reciprocating semi-rotary motion to the piston desired. Beyond the wheel and on the same shaft with it is the fly-wheel.

ROBERTSON VALVELESS ENGINE (ENGLISH).

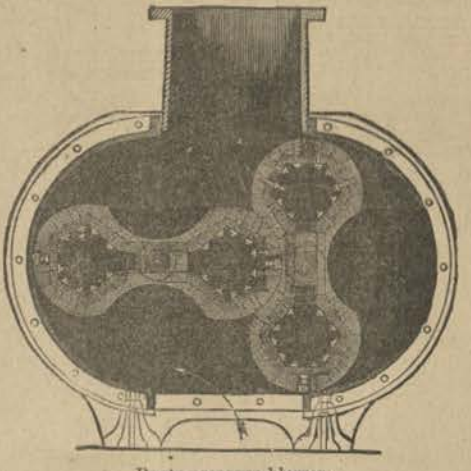


Robertson valveless engine.

This resembles essentially the Russian engine above described, except that the ball and socket-joint in the face of the wheel is replaced by a fixed pin projecting at right angles to the face of the wheel. This pin slides in a radial direction, through the rim of a disk on horizontal trunnions, in a fork formed in the nearest end of an arm on the piston-rod, similar to that of the Russian engine. The reciprocating motion of the piston-rod causes the wheel to turn; this in return alternately depresses and raises the arm and gives the piston the semi-rotary reciprocation desired. When in the revolution of the wheel the pin is at the ends of a horizontal diameter, it enters the disk to its fullest extent. It is drawn out as far as possible at the ends of the vertical diameter. This plan was devised by the inventor as an improvement on his original ball and socket model, shown in the Russian department, in order to provide a better means of taking up the wear on the working surfaces of the joint.

ROOTS PRESSURE BLOWER.

This blower acts upon much the same principle as a rotary pump, the air being caught between the wings of the revolvers and forced positively forward by their motion. As they turn they fit into one another and also touch the side of the case and so prevent escape to the rear. The revolvers are faced with wood boiled in paraffine to pro-



Roots pressure blower.

tect it from the effects of moisture. The contact surfaces are well lubricated. The principal advantages are in the forced continuous blast which they produce, and in the saving of power, only running at from 100 to 200 revolutions per minute. The blowers are geared together at both ends. Made by P. H. & F. M. Roots, Connersville, Ind.

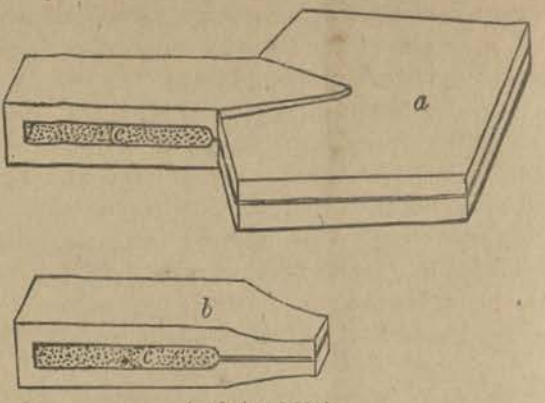
ROOTS HAND-BLOWER.

Shows a convenient method of operating a small rotary blower for blacksmiths' use, &c. A hand-lever is pivoted to an arm projecting from the frame, and also jointed to a crank-pin on the fly-wheel, which also drives the mechanism within the blower case. The motion is easy and natural, and the blow very compact. The lever may also be worked with a treadle. P. H. & F. M. Roots, Connersville, Ind. No. ½, adapted to one ordinary fire, costs $36.

PROCESS OF MAKING SOLID SHOVEL BLADES.

The loop *b*, is of wrought iron and is placed in a mold in which is cast the tool steel ingot *a*. The eye of the loop has been previously filled with a loam core, *c*. When cold the core is knocked out, the composite ingot heated to a low heat, rolled out, and trimmed into shape. The strips intended to embrace the shaft of the wooden handle separate along the line of the core, leaving the stem of the loop firmly

bound to the blade. The blade is rolled taper, leaving the greatest thickness near the helve.



Steel shovel blades.

RORER'S COMPOUND "UNION" BELTING.

This is made by firmly cementing between two or more thicknesses of leather one or more layers of heavy cotton duck and then riveting throughout the entire length. The canvas is continuous, and is stretched beforehand. The following tests are referred to by the manufacturer.

Strength: Oak-tanned leather broke, 1,200 pounds; one-ply Union belt broke, 2,625 pounds.

Stretch at 1,000 pounds: Oak-tanned leather, 3¾ inches; one-ply Union belt, 1½ inches; 2½-inch belts, 3 feet long.

Price of 4-inch belt, 51 cents.

Result of tests made at Centennial Grounds on Riehlé Bros. machine, July 3, 1876.

New York Belting and Packing Company .....rubber belt broke at 3,000 pounds.
National Rubber Company .....rubber belt broke at 3,500 pounds.
C. A. Schieren, New York .....leather belt broke at 3,375 pounds.
A. Burgess & Son, Providence, R. I .....leather belt broke at 2,250 pounds.
J. B. Hoyt & Co., New York .....leather belt broke at 3,500 pounds.
H. L. Fairbrother & Co., Pawtucket, R. I .....leather belt broke at 3,625 pounds.
Alexander Bros., Philadelphia .....leather belt broke at 3,000 pounds.
T. J. Rorer, Philadelphia, Improved Union belt .....5,625 pounds.
Anton Heim, New York .....leather belt broke at 3,375 pounds.
Page Belting Company, Concord, N. H .....leather belt broke at 3,250 pounds.
Josiah Gates & Sons, Lowell, Mass .....leather belt broke at 3,750 pounds.
E. B. Ritchie, Philadelphia .....(rawhide) broke at 2,875 pounds.
Anton Heim, New York .....(sugar tanned) broke at 2,000 lbs.

Thomas J. Rorer, 112 North Third street, Philadelphia.

RUSSIAN MECHANICAL SCALES FOR CARTRIDGES.

The Russian War Department exhibits photographs of automatic cartridge scales, which are said to be sensitive to from 0.0025 to 0.0005 of the weight, and to weigh 30,000 cartridges in ten hours. The ma-

chine costs 2,500 francs at St. Petersburg. The machine is essentially as follows: To the tire of a horizontal wheel are fastened eight radial scale beams. The pans of these are filled automatically from a feed box. The inner end of the beam is reduced in size and enters an irregularly shaped groove in the periphery of the standard. A portion of this groove opposite the feeding point is made rather wide; then the groove narrows to the width of the inner end of the beam, and divides into two branches which symmetrically diverge and again converge nearly at the feeding point, forming a curve lozenge shaped in elevation. The wheel being caused to revolve slowly, brings the inner end of each loaded scale beam opposite the first point of the lozenge. If the cartridge be light, the scale beam takes the lower branch of the guide groove and raises the cartridge to a point from which it is swept off into a locked box. If the cartridge be heavy *enough*, the scale beam selects the upper branch of the guide groove, and the cartridge is thus lowered to a point from which it is swept into the accepted work. The scales oscillate on rolling axles instead of on knife edges. They are said, in consequence, to require much less attention.

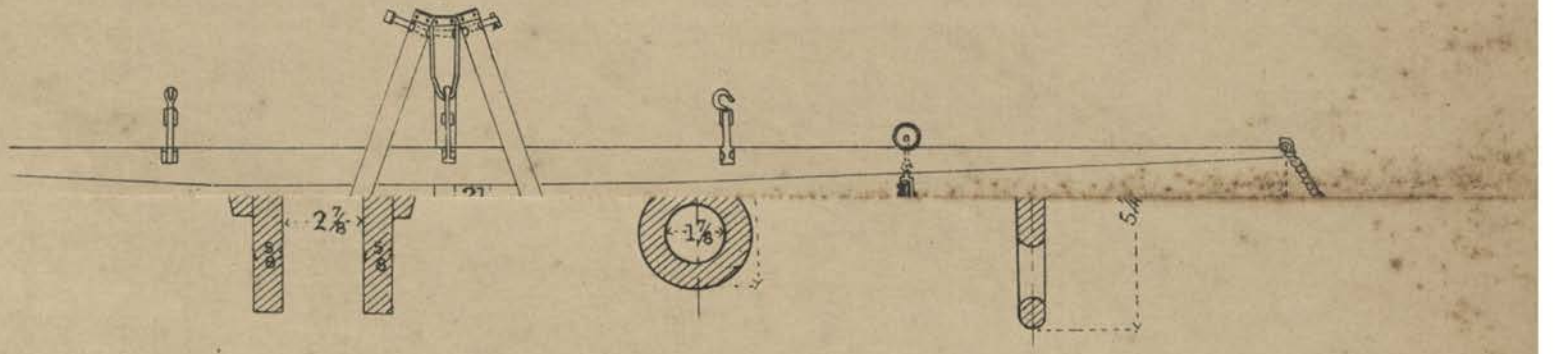
RUSSIAN TRAVELING CRANE.

The Russian Groosokat or portable traveling crane is intended to form a convenient means of moving light stores in places where the distance is too short for a railroad track and too great for the ordinary swing of a jib crane. It is intended principally as a substitute for carts or hand labor. It consists essentially of an approximately horizontal balk suspended from derricks, and forming an overhead tramway for the passage of a wheeled truck from which the object transported is suspended. By an adjustment of the derrick tackle the proper inclination of the balk may be given, so that the load once hoisted and attached to the car at the upper end of the balk will descend by the force of gravity alone.

The following means of passing the points of suspension are provided. Generally there are two methods adopted; one, where the balk is solid and the truck is slit, as seen in plans B, C, D, the two wheels running on the upper edges of the balk, and being connected by a stirrup underneath it, the space between the wheels being left open for their passage by the suspending bolt. The other plan is the converse of this, involving the use of a split balk, and a solid truck. This method is shown in plan A. In this case the balk is suspended by an overhead stirrup, the wheels running between its branches and the sides of the balk. From the axle which unites the wheels an eyebolt is suspended for the load. It is evident that the necessary stays between the sides of this balk restrict its use to short distances as in the transfer of stores between boat and cart, cart and car, where the means of transportation can be brought near each other before the crane is used. By uniting several of these balks together either by external straps, as shown in D,

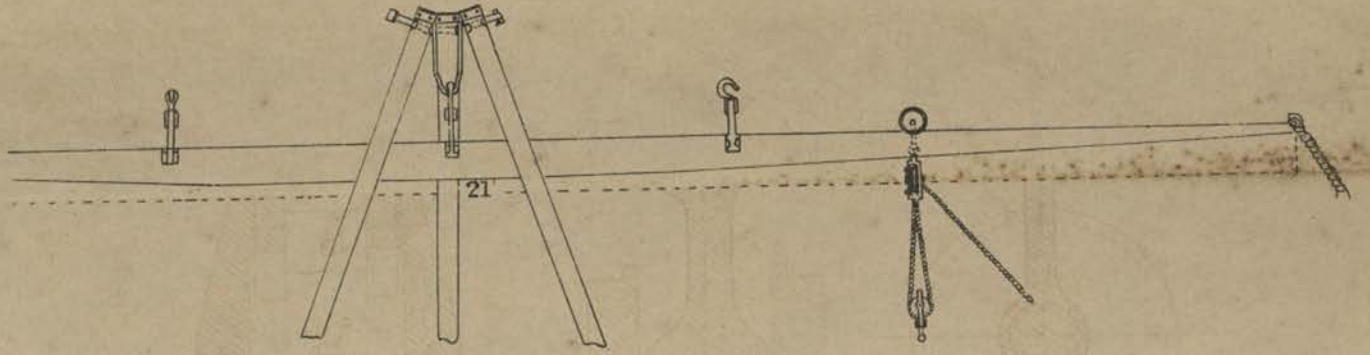
The Groosokaf, or portable traveling crane.

A No. 1



RUSSIAN TRAVELING CRANE.

A No. 1



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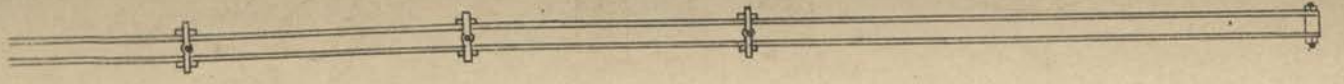

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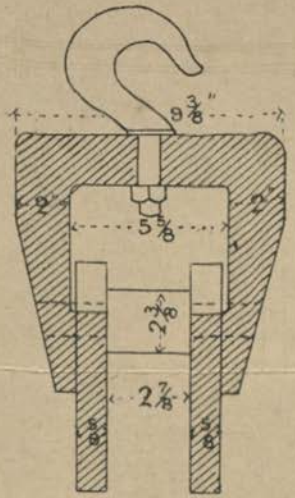
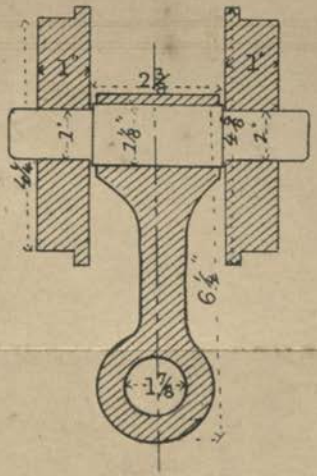
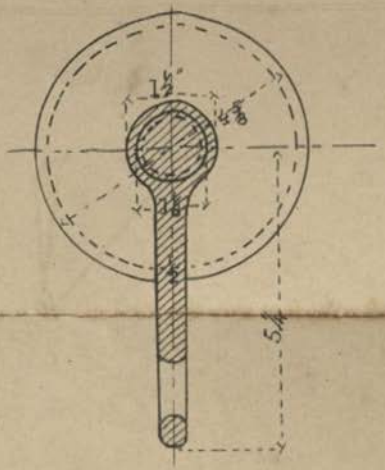


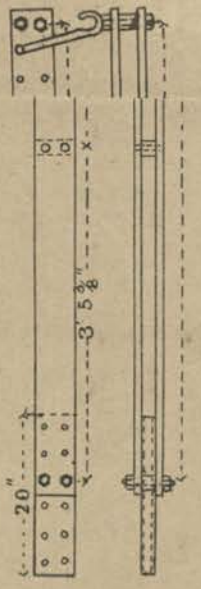
A No. 4

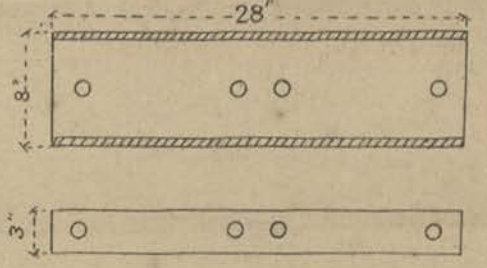


A No. 5

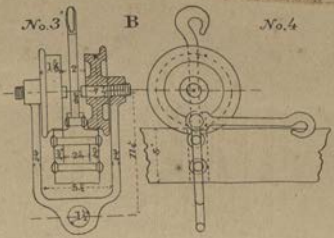


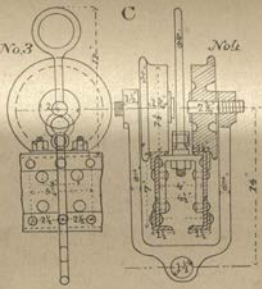
RUSSIAN TRAVELING CRANE.

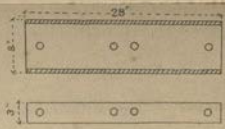




RUSSIAN TRAVELING CRANE.

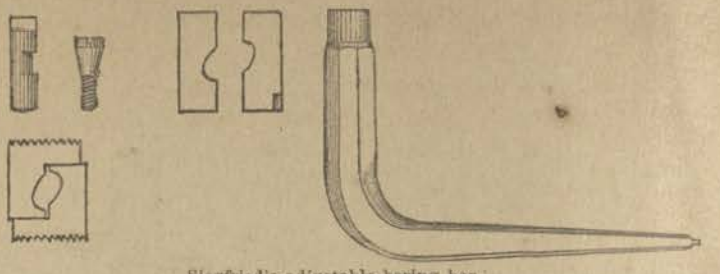






RUSSIAN TRAVELING CRANE.

RUSSIAN TRAVELING CRANE.



Siegfried's adjustable boring bar.

SELLERS HYDRAULIC PROCESS FOR UPSETTING EYE-LINKS.

A steel bar 2.5 by 9 inches is shown upset at each end to a circle 20.5 inches in diameter containing a 6.5-inch hole. This was done at two heats, by laying a short piece of iron across the end to be upset before subjecting the bar to the welding hydraulic pressure. When heated and pressed the two thicknesses furnish all the stock needed for the enlargement of the bar. This is preferred by Mr. Sellers to the ordinary process where the iron is upset endwise, causing a wavy structure and possible demoralization of the metal.

SIMPSON'S ADJUSTABLE VISE.

The body of the screw appears to work in a half nut above it, attached to the under surface of the sliding jaw. The slide of this jaw is allowed a slight vertical play in the mortise through the standing jaw, so that the half-nut may be lifted off the screw at pleasure, and set at any desired point of its length.

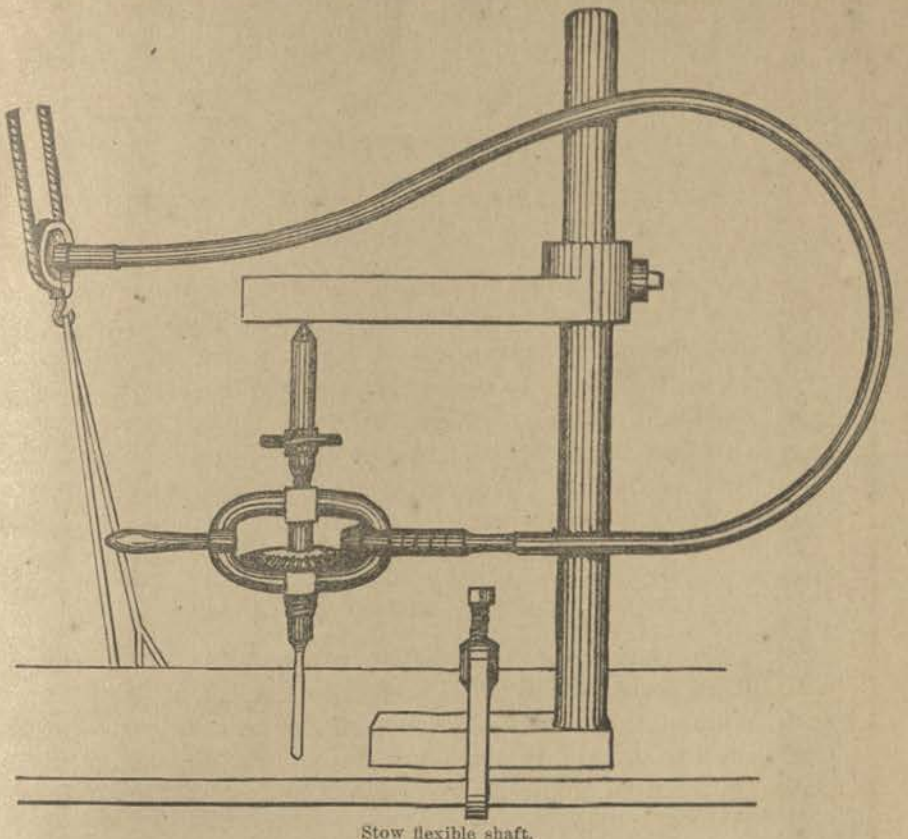
Bailey Wringing Machine Company, 106 Chambers street, New York. Stationary bench-vise, 3½ by 5 inches, $8.

THE STOW FLEXIBLE SHAFT.

This consists of a series of concentric tubes, made of close spiral layers of steel wires wrapped under tension and brazed together at their loose ends. One end of this shaft being fastened to the axis of the driving pulley, the other end may be taken in any direction and through any number of curves to the working point. Its principal application is for drilling and surfacing. The shaft is covered with a loose sleeve of leather within which it rotates. It is shown in operation boring holes in wood in any desired position, as well as drilling iron. A simple hand clutch is used, which permits motion to be given to the tool, or withdrawn from it at pleasure, without stopping the machine. In drilling iron the ordinary brace is employed; in wood, the simple

pressure of the hand aided by the draw of the tool is sufficient. A flexible shaft 1¼ inch diameter, 8 feet long, made of eight layers of No. 16 steel wire, with the necessary fixtures, costs $50.

Address, No. 500 North Fifteenth street, Philadelphia.



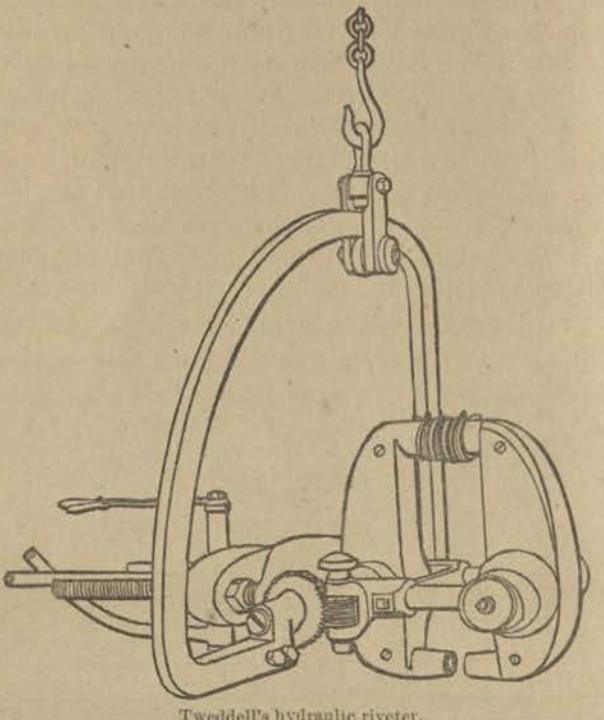
Stow flexible shaft.

TWEDDELL'S HYDRAULIC RIVETER.

This machine, exhibited by William Sellers & Co., is intended to be worked by hydraulic pressure, so as to upset slowly but surely, and with an equal force, the rivets requiring its action. Hydraulic pressure produces a better rivet than hand-hammering, in that the whole body of the semi-fluid rivet is attacked and laterally expanded; whereas in hand-riveting the effect is apt to be merely local and in the immediate vicinity of the blow. This is abundantly shown by sections of plates riveted in part by hammering, and in part by hydraulic pressure, especially where the holes do not exactly coincide. Another feature of the machine is its lightness and portability, being swung by a differential pulley from an overhead traveling crane covering a space 50 by 6 feet. By a system of pointed hydraulic pipes it is kept in communication with the accumulator—a familiar device by which water is constantly pumped into a cylinder loaded with a number of heavy weights capable of giving a maximum pressure of 2,000 pounds per square inch. The pump has a relief valve, which opens when the desired pressure has

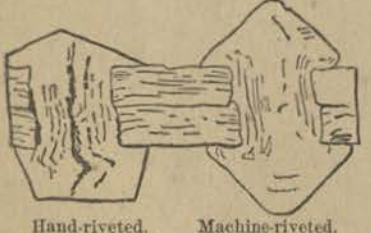
been attained, and, shutting off the water in the accumulator, returns the water drawn from the reservoir by the pump back to the source from which it came.

This machine itself consists of a riveting die and a holder, one or the other attached to and moved by a piston in a cylinder, which is called the compressing cylinder; this cylinder communicating with the



Tweddell's hydraulic riveter.

accumulator through a valve, not self-acting, but moved by the operator, so that when the valve is opened the piston, to which the die or the die-holder is attached, invariably moves until the rivet is headed, with a force which is positively defined by the pressure on the accumulator. Hence the work is performed without a blow; the pressure is uniform whether the rivets are long or short; it can be modified by the weights applied to the accumulator; it is continuous for each rivet, and may be maintained as long as desired, or the riveting die can be retracted as soon as the rivet is finished, whether the pump is taking water, delivering it, or at rest. The riveting dies are placed in the short ends of levers of the second order, in which the power is applied at two-thirds the length from the fulcrum. This allows a jaw opening one-third the length of the lever, for reaching rivets situated at that distance from the edge of the work. The stationary lever is secured



Hand-riveted. Machine-riveted.

by heavy straps to the cylinder. The fulcrum is made in a half ball and socket joint kept closed by a spiral spring.

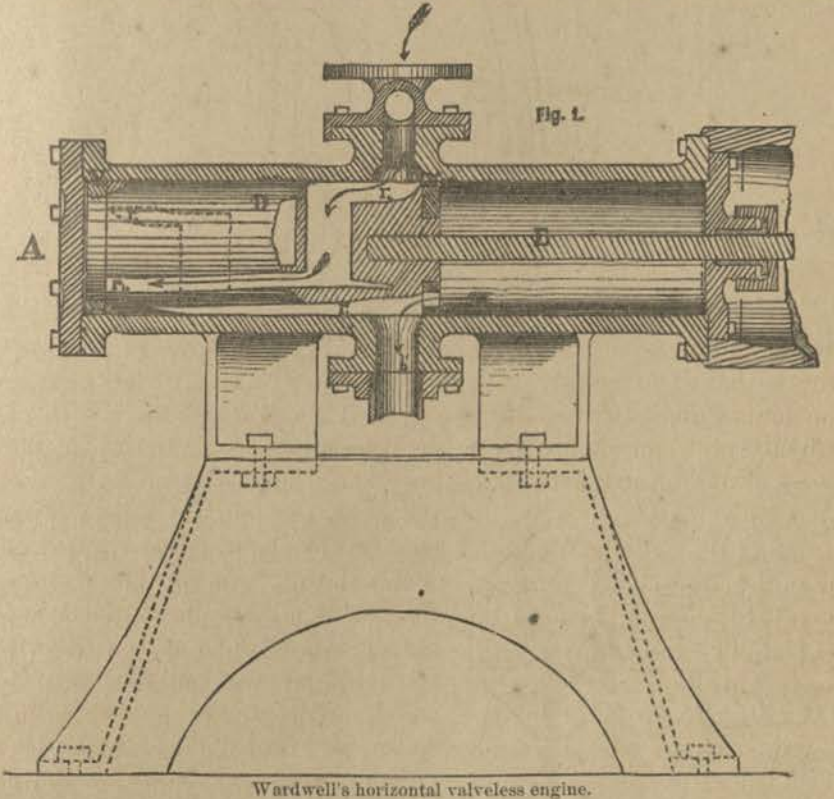
A small worm-gear is shown by which the riveting-machine proper can be swung on its trunnions to any desired degree of obliquity. The sectoral bail by which it is suspended allows of its being used as well on oblique or vertical seams.

The work to be riveted rests on trestles, and the riveting-machine is moved along or around it. The operation is as follows: One man raises and lowers the rivets, adjusts the machine to the rivets, and then closes the dies on the rivets by moving the handle shown in the sketch. Boys drop the red-hot rivets into place with the head of the rivet uppermost in horizontal work. With a skillful operator as many as 6 to 10 red-hot rivets may be put in place ahead of him and he can on beam work drive from 10 to 16 rivets per minute.

The cost of a machine with 18-inch jaws, riveting 6 inches from the edge, is $1,120, including the bail.

WARDWELL'S HORIZONTAL VALVELESS ENGINE.

The main feature of this engine consists in a reciprocal rotary motion about its own axis, which is given to the piston by a simple transforma-



Wardwell's horizontal valveless engine.

tion of its own rectilinear motion when under steam. By this rotary motion the piston itself performs all the functions of a valve, and saves the cost of the steam-chest, valves, cut-offs, &c.

The horizontal 8 by 16 inches 15 horse-power engine is constructed as follows: The steam-port, 3 by $\frac{3}{4}$ inches, is in the center of the cylinder, on top. The exhaust-port is 3 by 1, and diametrically opposite. The steam-passages in the piston are seen in the sketch. They are open grooves which run along the cylindrical surface of the piston in a longitudinal but (elliptically) curved line, which keeps the passage open to the cylinder-port up to that part of the stroke and rotation where the cut-off is desired. Here the cut-off is effected by turning the passage sharply at right angles, and in the direction of the piston rotation, giving the rest of the stroke under expansive steam. The steam-passage, after the abrupt turn mentioned, continues longitudinally to the end of the piston. At the end of the stroke it is in communication with the exhaust-port of the cylinder, and immediately acts as the exhaust-passage. Another similar passage on the other side of the piston alternates with it for steam and exhaust successively.

Figure 3 represents the development of the cylindrical surface of the piston, with a face view of each of its ends; and Fig. 2, a broken sec-

Fig. 3.

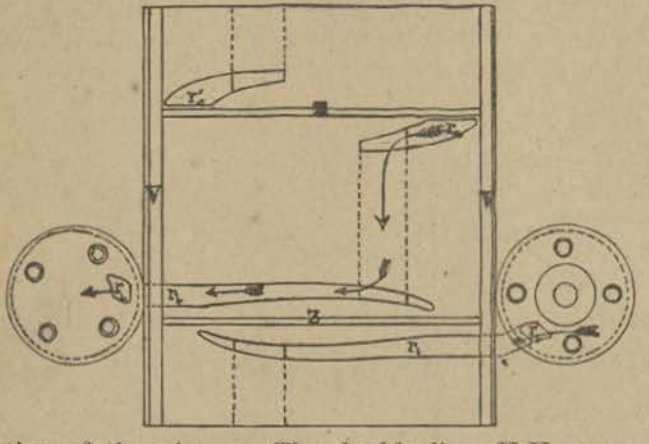
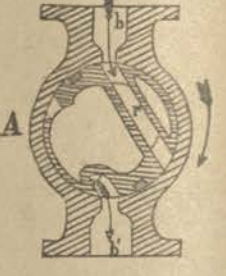


Fig. 2.



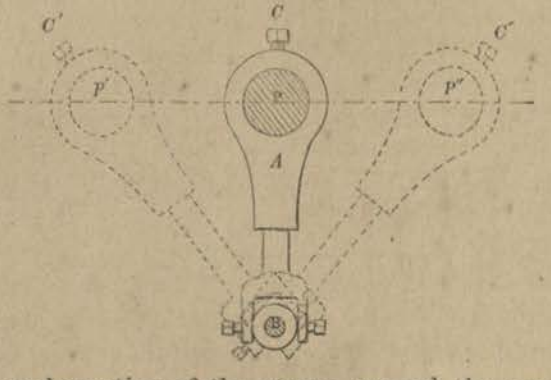
tion of the piston. The double lines V V represent the end-spring packing-rings, and the lines Z Z two longitudinal spring packing pieces, designed to shut off communication between the two sets of steam-passages on opposite sides of the piston. Supposing the piston at the bottom of the cylinder, the steam enters, as shown by the arrow, through the port b, and passes along the piston through the steam-passage r_a. Then it turns around the piston under the surface, and then again along the piston on the surface, until it issues through the opening r_b, in the rear face of the piston. This produces a pressure which impels the piston in the direction A E, giving it at the same time by other means, to be described, a rotary motion the reverse of that previously acquired. The steam admitted on the previous stroke into E escapes meanwhile through the passage r_b' into b'. At the end of the stroke from A to E the passage r_b finds itself over the exhaust-port b', and thus allows the steam to escape during the stroke from E to A, due to the entrance of

the steam from b into r_a'. The exhaust-passages are slightly prolonged to form cul-de-sac steam cushions. An elliptical form is also given to the exhaust passages r_b, r_b', to keep them in constant communication with the exhaust-port during the backward rotary motion of the piston. The four circles in each piston-head are bolt-heads.

It will be observed that the cut-off of this engine is invariable. The engine shown cuts off at half-stroke. It is said that the plan is susceptible of practical application to one third stroke. It is evident that the piston-head requires to be longer than is the stroke of the engine. In the engine under consideration it is 19 inches. The manner in which the rotary motion is given to the piston is extremely simple. Inside the outer fork of the crank-rod of the horizontal engine is bolted a section of a bevel wheel with four teeth, which gears into a similar but five-toothed section, keyed to the extreme end of the piston-rod. This end of the rod being journaled in the cross-head, the ordinary longitudinal reciprocation of the piston-rod produces, through its connection with the crank, an oscillation of the crank-rod in a vertical plane, which, by means of the gearing uniting the two rods, is transformed into the reciprocating semi-rotary motion of the piston desired.

An 8 horse-power vertical engine of the same kind is shown containing a vertical oscillating cylinder. The piston-rod, Fig. 4, swivels

Fig. 4.

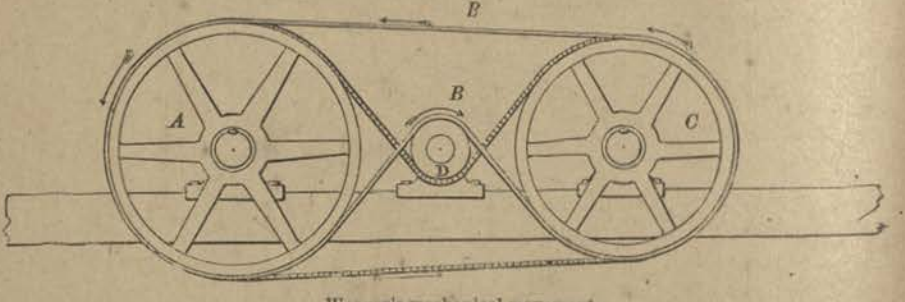


axially in the prolongation of the straps around the crank-pin. The reciprocating rotary motion is given to the piston by a horizontal arm, A, rigidly clamped to the piston-rod by C, and standing at right angles to its plane of oscillation. This arm is provided at its outer end with a swiveled brass box, through which passes a fixed vertical rod, B, fastened to the frame at each end. The arm consequently plays up and down this rod with the motion of the piston-rod. The rod B, by means of its connection with the piston, constrains the latter to revolve reciprocally on its own axis in harmony with its own lateral oscillations, giving the piston a turn to the left when it oscillates to the right of the rod, and *vice versa*. Allowance is made for the difference in length of

this arm in different positions of the piston-rod by having it made in two sliding sections, telescoped. This motion is rendered evident by the sketch, Fig. 4, in which P P′ P″ represent in horizontal section successive positions of the piston-rod, when on the center and at the extreme ends of the horizontal throw of the crank. A is the horizontal arm, B the fixed vertical rod, C C′ C″ successive positions of the set-screw binding the horizontal arm to the piston-rod. While the piston is moving from P to P′, the line B C joining the centers of P and B has changed to the position B C′, giving P a rotary movement = C B C′ upon its own axis. This motion is reversed at each of the extremities of the horizontal diameter of the circle of revolution of the crank. The advantages claimed for this engine are its durability from lack of steam pressure on valve surfaces, the quickness of its cut-off, its rapid exhaust, and especially the economy of its manufacture, a 15 horse-power engine costing only $500 in the market. This price is estimated, as only the two engines described have yet been built. Two other engines of this class are exhibited, one in the Russian department and one in the English department. Each of them has four steam-passages, two for the live steam and two for the exhaust, requiring the useless filling of the exhaust-passage with steam at each stroke. These are described elsewhere.

WEAVER'S MECHANICAL MOVEMENT.

This consists, as shown in the sketch, of three pulleys set in line in the same plane, both of the outer pulleys serving to drive the inner smaller



Weaver's mechanical movement.

one on the tool-shaft, or which may be the body of the tool-shaft itself. This is done by means of the reverse belts B B′ passing around driving-pulley A under and over tool-shaft D, around loose pulley C, which runs on a shaft attached to an adjustable lever by means of which the belts may be tightened at will. By this arrangement of belts nearly the whole circumference of the small pulley is enveloped by the belts increasing the power transmitted without strain on the boxes in which the tool-shaft runs. The periphery of the driving pulley is formed in two square grooves to keep the belts separate.

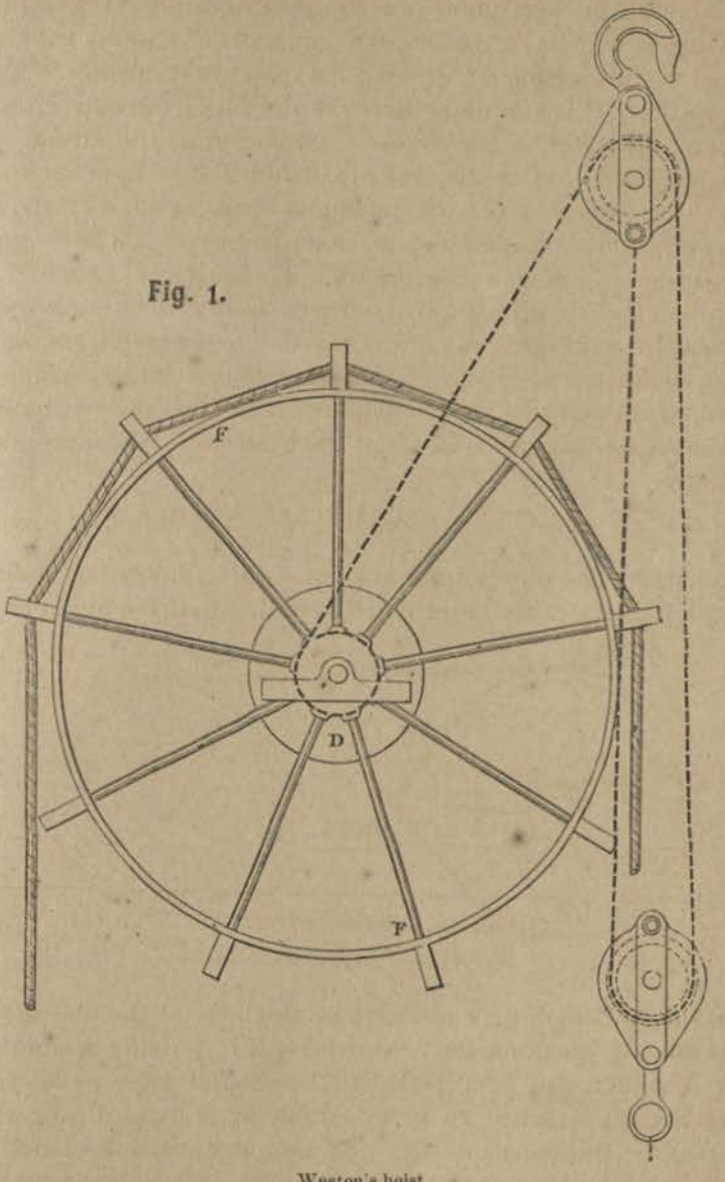
WESTON'S HOISTS.

The display of these machines embodies four distinct points variously combined.

I.—*The circular friction coupling.*

The apparatus consists of two series of friction disks, arranged alternately with each other upon a common axis, one series being carried by

Fig. 1.

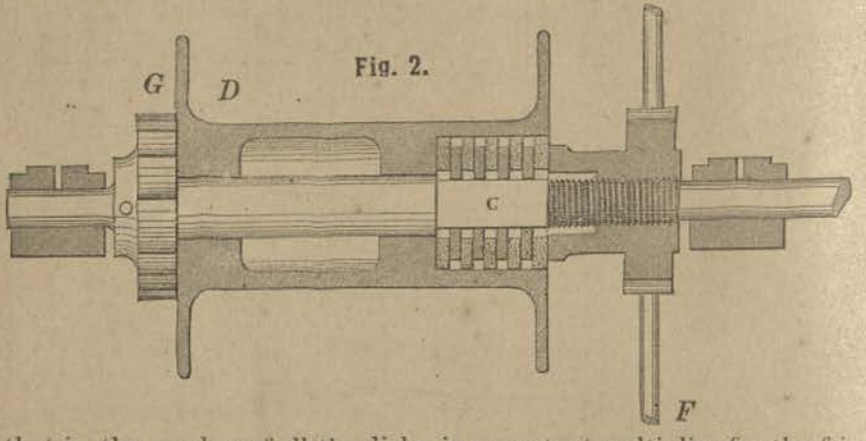


Weston's hoist.

one shaft, and the other series connected to the other shaft or wheel which is required to be coupled with the shaft. The disks on the first shaft cannot turn independently of it, but can slide lengthwise upon it towards or from each other. This series of disks are for convenience called

the "shaft-disks" in the following description. Arranged alternately with them are the disks of the other series, which have each a circular opening sufficiently large to clear the shaft entirely; but at their outer edge they are slotted or made polygonal, or otherwise fitted in their outline to an external drum or cylinder containing them, so that they cannot rotate independently of the drum, but they slide longitudinally within it. These disks are called for distinction the "intermediate disks." So long as no longitudinal compression is applied to the disks, the shaft disks with the shaft carrying them are free to rotate independently of the intermediate disks and the drum containing them; but upon compressing the disks together longitudinally into frictional contact, the rotary motion of one series is either transmitted wholly to the other series, or is controlled or arrested by friction against the disks of the other series, and the series of disks acts thus either as a coupling or as a brake. The great advantage arising from the alternate arrangement of the disks is that the frictional effect of any pressure applied to couple them is repeated as many times as there are disks in the two series;

Fig. 2.



that is, the number of all the disks is a constant multiplier for the friction produced between a single pair of the rubbing surfaces by any given pressure. Where the space available for a friction coupling or brake is limited in a radial direction, so that the disks are required to be small in diameter, the necessary amount of friction is obtained by extending the coupling lengthwise along the shaft, employing an increased number of the disks to compensate for their small diameter. On the other hand, where the space is limited longitudinally upon the shaft, involving the use of fewer disks, their diameter can be increased to give the necessary amount of frictional surface. The materials and structure of the disks may be various. For the severest strains both series of disks are made of iron, one series being faced with wood segments placed endways of the grain.

In Fig. 1 is shown a sack-hoist, as used without tackle-blocks, and with the blocks it forms a convenient hoist for weights up to a half ton. Fig. 2 a longitudinal section to a larger scale. The winding bar-

rel D is loose upon the shaft, and is recessed at one end to form the brake-drum. The coupling and brake are arranged as follows: The five iron shaft-disks fit upon the square part of the shaft C, and the intermediate wood disks engage with the ribs inside the drum D. The rope-wheel F is screwed to traverse upon a screwed portion of the shaft. A

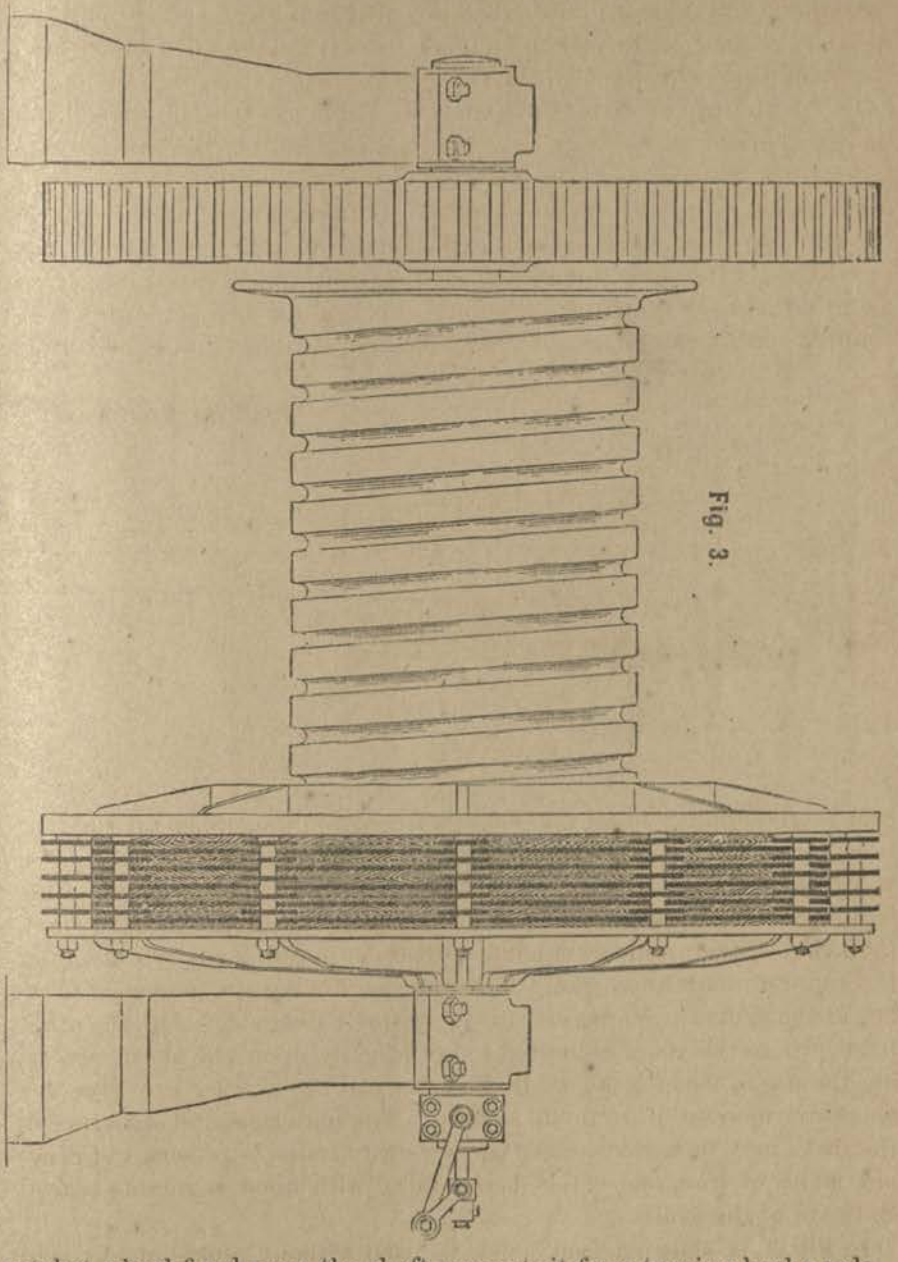


Fig. 3.

ratchet-wheel fixed upon the shaft prevents it from turning backwards, and also forms a collar or abutment to receive the coupling pressure applied by the screwed boss of the rope-wheel. An endless rope passes

over the rope-wheel, and on pulling the rope in the direction for hoisting the rope-wheel advances upon the screw and compresses the friction disks until the friction between them is sufficient to couple the winding-barrel D to the shaft C. On continuing the hoisting motion the load is then raised, and is held suspended at any point by the ratchet-wheel G. For lowering the load it is only necessary to pull the rope in the opposite direction, and as the shaft cannot turn backwards on account of the ratchet-wheel, the rope-wheel is thereby withdrawn, relieving the friction-disks from pressure; and the winding-barrel be-

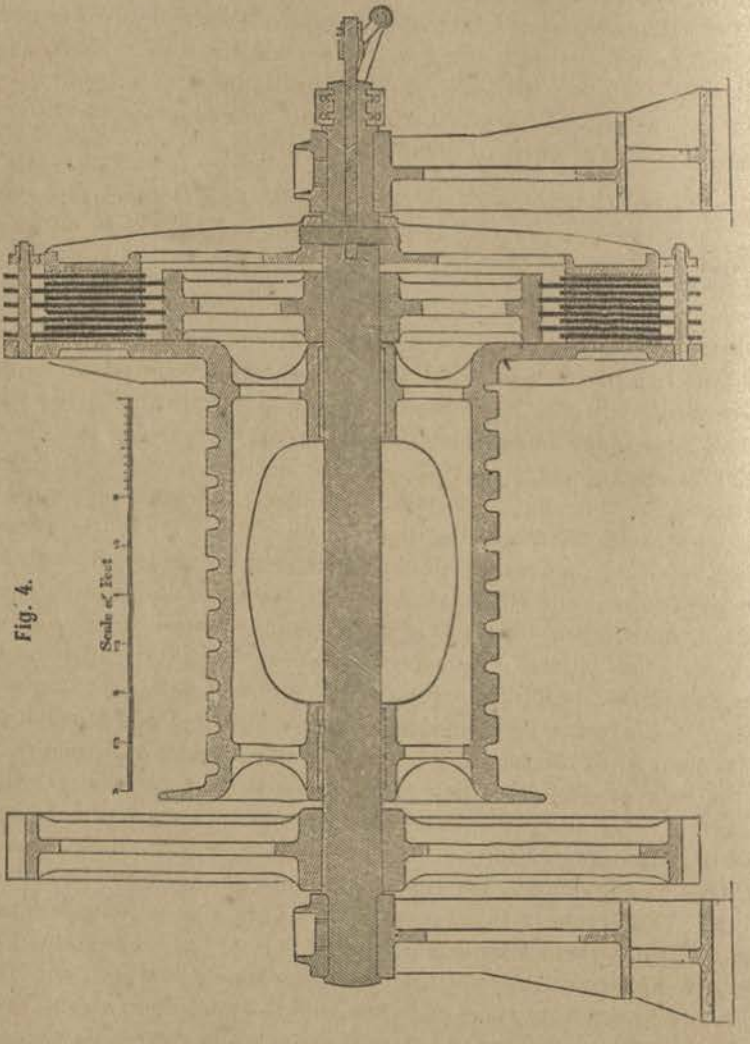


Fig. 4.

ing thus uncoupled from the shaft runs backwards on it with the load. The speed of lowering is under perfect control by holding the endless rope with one hand on each side, and applying the brake as required to check the descent of the load by pulling the rope slightly in the

direction of hoisting, so as to screw the rope-wheel up against the friction-disks. This arrangement of hoist has the advantage that both the hoisting and the lowering are done at pleasure by means of a single endless-rope, which affords perfect control over the load at all times.

The disk-brakes used in the grapple dredging-machines of the American Dredging Company at Philadelphia, Figs. 3 and 4, have 150 square feet of friction surface. The disks are between 6 and 7 feet in diameter. They are compressed by a "toggle" pinching apparatus, operated by a long lever. The chain worked thereby is of ⅞-inch iron, and capable of carrying a maximum load of 30 tons. One man handles two of these drums with ease, controlling the descent of the load upon either chain with precision by direct friction. The wear upon these brakes is inappreciable. As the surfaces are flat, there is no possibility of sticking; and the transmittal force is always a true and constant multiple of the initial pressure applied to compress the friction faces.

II.—*Circular inclines or screw faces operated by a hand-wheel for controlling the brake and by which also the brake action is made automatic.*

The action of this can be well understood from examination of Fig. 5, in which is shown a sack-hoist, intended for small weights up to 5 cwt., and possessing the valuable property of being self-sustaining, so that the load can in no case run down of itself, but requires to be lowered continuously by the hand-rope. The rope-wheel F and the winding-barrel D are both loose upon the main shaft C, between the small fixed collar E and the large disk H, coltered on the shaft; a ratchet-wheel, G, keyed on the shaft between the collar E and the rope-wheel, prevents the shaft from turning backwards. The boss of the rope-wheel F has its outer face made plain and smooth for frictional contact with the adjacent side of the ratchet-wheel G, and the flange K at the other end of the winding-barrel D is in like manner faced to rub against the disk H. The side of the rope-wheel boss F, that is adjacent to the winding-barrel, is formed with a spiral inclined face, I, or single convolution of a screw, which engages with a similar spiral incline, J, formed upon the end of the winding-barrel D. The diameter of the other side of the rope-wheel boss which rubs against the ratchet-wheel G is made rather greater than the diameter of screw inclines I and J; and the pair of rubbing faces formed by the flange K and the disk H are made as large as convenient, for the purpose of gaining brake-power in lowering. The action of this construction of hoist is as follows: On turning the rope-wheel forwards in the direction for raising the load the inclined surface of the spiral between the rope-wheel and winding-barrel tends to separate them endways, and thus produces an end pressure, which tightens together the external plain rubbing surfaces with a pressure proportionate to the load sustained by the winding-barrel. The rope-wheel and winding-barrel are thus jammed between the fixed collars E and H on the shaft, and the several parts of the hoist are thus

firmly coupled together so that the continued forward rotation of the rope-wheel F carries with it both the winding-barrel D and the shaft C, thereby raising the load and turning the ratchet-wheel G forwards. The pawl is fastened to some portion of the frame not shown. For low-

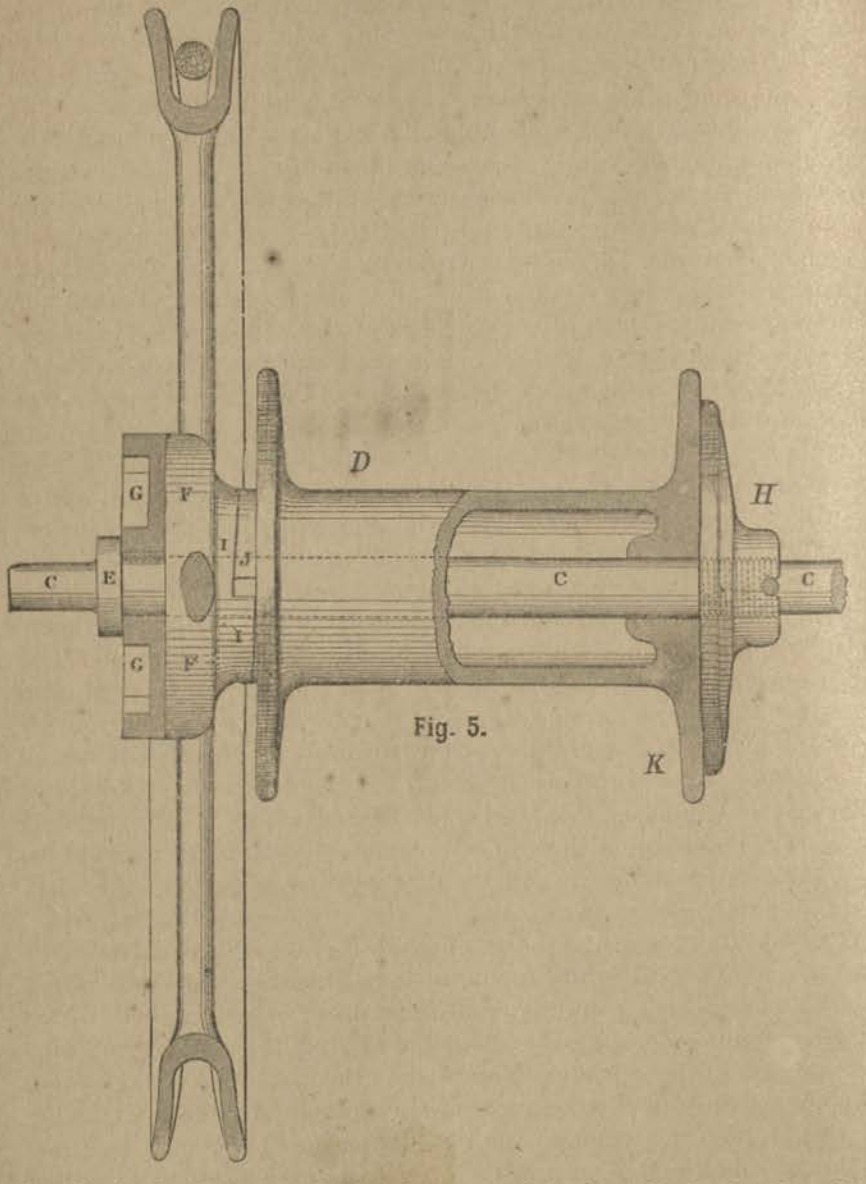


Fig. 5.

ering the load, the rope-wheel being turned backwards by hand, withdraws one incline from the other in the spiral clutch, and thereby relieves the friction surfaces from the end pressure, so that the winding-barrel is released and the load can descend; but the descent of the load can only take place so long as this withdrawal of the inclines is contin-

ned by the rope-wheel continuing to be turned backwards by hand, allowing the winding-barrel to follow. The moment the rope-wheel is stopped, the inclines become tightened again upon each other by the load acting on the winding-barrel; the rope wheel and winding-barrel are thus again jammed endways between the friction surfaces of the ratchet-wheel G and disk H, which, being held by the ratchet from turning backwards, prevent the load from running down further. When the proportions of the parts have been suitably adjusted for sustaining any given load, the self-sustaining and self-arresting property of the hoist is not affected by any increase or diminution in the load, because any change in the load is attended with a proportionate change in the amount of end pressure produced by the inclines and in the consequent frictional resistance offered by the rubbing surface of the ratchet-wheel. Under any load whatever, the moment of the frictional resistance or adhesion between the rubbing surfaces of the ratchet-wheel and the rope-wheel boss arising from the oblique action of the inclines is always greater than the direct rotary driving force of the winding-barrel upon the rope-wheel through the inclined faces of the spiral clutch. With the proportions above mentioned the sustaining friction is so little in excess of the load that only a slight amount of force is sufficient to turn the rope-wheel backwards for lowering the load; and the rope-wheel being made heavy to act as a fly-wheel, a tolerably vigorous pull upon the rope causes the wheel to make a number of revolutions backwards, allowing the winding-barrel to follow and lower the load with proportionate rapidity. But as the frictional resistance slightly preponderates, the lowering takes place with perfect safety, and the load gradually ceases to descend as the rope-wheel loses its momentum. The lowering of the load, therefore, continues only so long as the backward motion of the rope-wheel is continued by hand, and the descending load comes to rest at any moment that the rope-wheel ceases to be turned backward. The endless rope thus affords the means of both raising and lowering weights continuously and steadily, by simply working the rope-wheel by hand in opposite directions; and at the same time all possibility of accident from the load running down of itself is avoided. This construction of hoist is also capable of very advantageous combination with the friction disk, coupling, and brake previously described, where a large amount of brake-power is required; but for a variety of purposes the use of the spiral inclines renders the addition of the friction disks unnecessary. Where great power is required without excessive end thrust upon the windlass the two methods are combined by causing the circular incline or spiral clutch to actuate a series of friction disks in the manner indicated in No. I.

NOTE.—The greater part of the above is taken from a paper prepared by Mr. Weston for the British Institution of Mechanical Engineers.

III.—*Ratchet connections.*

The construction of these ratchets is peculiar and requires preliminary consideration. Suppose it be required to connect two shafts end to end so that they will revolve together in one direction only. Imagine one of them with a set of four ratchet teeth on its end, the planes of the straight faces of the teeth being axial. Imagine three spring pins projecting from the adjacent face of the other shaft, parallel to its axis and equidistantly arranged about its circumference. This will make a differential ratchet, the moving space never being more than one-third of the interval between the teeth, or one-half of the circumference of the circle. This obviates the weakness of construction consequent upon making the ratchet with 12 teeth, and also renders the arrangement so compact that it may be applied within the body itself of the driving pinion. Supposing then that the handle for a winch be connected to a shaft containing two of these ratchets, working in opposite directions, and

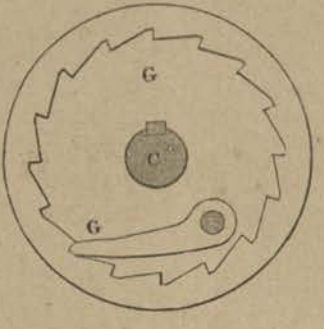


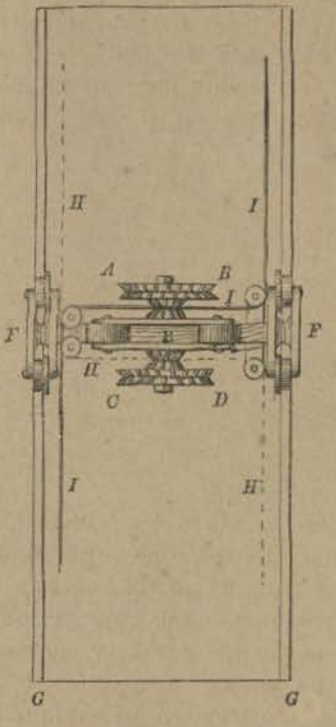
Fig. 6.

that one of the pinions to which they belong, engages with a certain train of gearing leading to the rope drum, and that the other pinion engages with another train of gearing of a different power, leading to the same drum; different speeds in hoisting can be obtained by simply reversing the movement of the crank, a separate hand-wheel or crank being provided for the self-arresting safety lowering motion. An application of this principle, difficult to explain without a special drawing, is made in the case of a "3-speed" overhead hoist, to be operated from below. Two endless hand-chains afford the choice of either one of the 3 speeds in hoisting, with the self-arrested safety motion for lowering direct from the barrel, without disturbing the gearing and shafts. The first of these endless hand-chains gives a treble purchase if pulled upon one side, and upon the other side a single purchase; the second gives a direct hoisting motion on one side, for coiling up the slack chain rapidly, or hoisting a light load; and on its other side it gives the self-arrested safety lowering motion, or serves to run off the unloaded chain rapidly from the barrel when required. The motions are each capable of instant use without the intervention of the clutches or levers encumbering ordinary hoists, the use of which always involves loss of time,

and sometimes accidents. One of the endless chains is connected with a pair of ratchet pinions as described, and the other endless chain is connected directly with the drum of the hoist, replacing the crank handle described under head II.

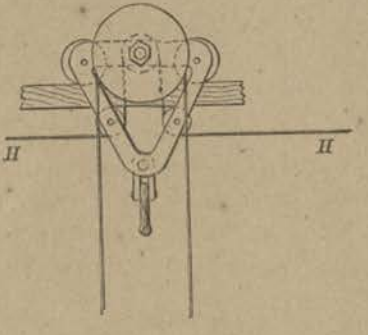
Yale Lock Company, makers, Stamford, Conn.

The *Traveling Crane*, when arranged to be worked from below, has all its horizontal motions controlled by two endless hand-chains or ropes, hung from two sprocket wheels upon the crab or truck E, in the sketch, which is a plan, or bird's-eye view. G G are the rails or track, spanned by a girder or bridge, F, which has the usual pulley wheels at its ends F F.



The truck E has the usual traveling wheels for traversing upon the bridge F, and it may suspend a differential pulley for hoisting the load, or carry a geared hoist and winding drum of any desired capacity. Upon pivots fixed to the truck E are carried the sprocket wheels A B and C D. Each one has cast upon it a small chain wheel, to gear with and grasp the chain cables; A B acting upon the chain I, and C D upon H. The cables are strained at their extremities by weights or springs to keep them taut. Guiding sheaves are fixed to the bridge, where the cables turn at an angle, and also on each side of the chain wheels to hold the cable in gear with them; the latter are shown in the small sketch. The four pendent sides of the two hand chains or ropes can be referred to as the sides A, B, C, D. By pulling A and C downwards together, the truck E is propelled —→ along the bridge; by pulling B and D

together, the truck moves — on the bridge. In both cases the chain wheels rotate together in the same direction, traversing over the parallel cables crossing the bridge, and taking the truck with them. By pulling A and D together, the truck remains at rest on the bridge, but the bridge is propelled ↑ towards the north end of the railway. By pulling B and C, the bridge is moved towards ↓ the south end. In the two last named cases, the sprocket and chain wheels are rotated in contrary directions. Diagonal motions are obtained by pulling A, B, C, and D singly. Thus, A gives motion in the ↗ direction, B ↙, C ↖, and

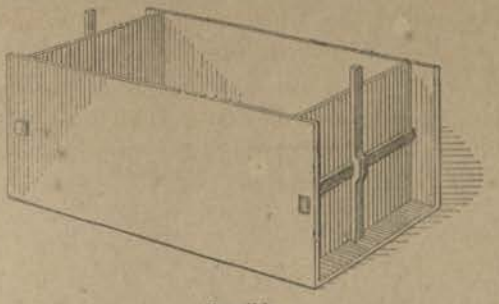


D ↖. These diagonal motions are of course due to the combined movement of the truck crosswise of the bridge, and of the bridge lengthwise of the railway. The movement of the truck upon the bridge is due to the direct pull on the one cable so acted on. The drag of the idle sprocket wheel and attachments upon th other cable, as the truck moves, tends to propel one end of the bridge towards the fixed extremity of that cable; the other end of the bridge is pulled parallel the same way, by the cable directly acted on. The two forces acting respectively upon the ends of the bridge are not equal, but are sufficiently so to keep the bridge approximately at right angles with the railway. The direct traveling motion of the bridge upon the railway is square to the rails, with no tendency to jam or run off, however wide the span, and irrespective of the position on the bridge of the truck which carries the sprocket wheels.

WHEELER PROCESS FOR MAKING IRON COVERED STEEL.

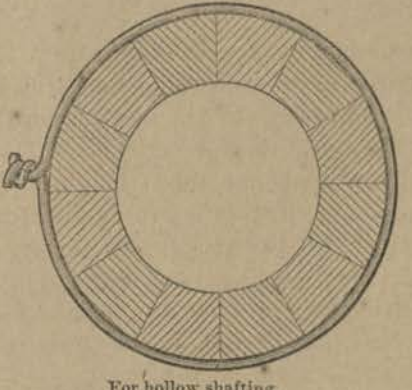
A crucible is made up as shown in the sketch from six pieces of plate iron loosely put together by rods of flat bar iron at the ends. This is filled with scrap steel, preferably in such small pieces that it would ordinarily be unserviceable as scrap. The lid is then put on and secured by tapping down the upright rods at the ends which pass through holes corresponding to those in the bottom plate. The crucible is then heated until the iron is at a welding heat. The steel is then in a soft or semi-molten state and intimately united with the interior surface of the crucible. At the proper moment the entire mass, crucible and all, is re-

moved from the furnace and passed through the rolls. The iron is proportionately reduced and is plainly evident, even in ¼-inch wire reduced from the original mass. The object of the iron coating is to afford a



Crucible.

welding surface when it is desired to unite steel bodies together, and also to allow steel to be forged without danger of burning it. This is well shown in the case of horseshoes made from this material, which can be forged and have the toe calks welded on as easily as in the case of an iron shoe. An application of this material to the manufacture of



For hollow shafting.

cannon is shown by model on a small scale, the steel forming the bore. It is said that even the thin skin of iron strengthens a steel rod to such an extent that it may be bent far beyond the ordinary limits of safety. A method is also shown for rolling hollow shafting by building up the pile for the rolls from bars of trapezoidal section, which are tied together in billets with iron wire. This shafting is said to be as strong as solid shafting and to cost no more for labor, the saving being in material.

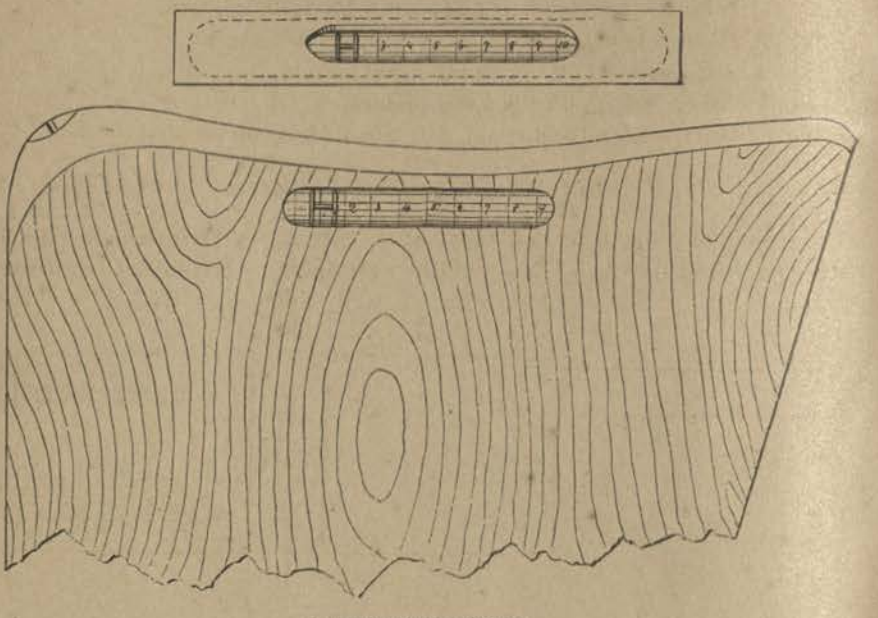
WOVEN HAIR BELTING.

Hair machine belting, for use out of doors or in water, made of horse hair (?) plaited in with a small quantity of linen twine and painted with metallic paint; 10^{cm} wide. About the same price as leather.

Class G.—INSTRUMENTS.

LE BOULENGÉ RIFLE TELEMETER.

Le Boulengé exhibits the rifle telemeter fitting into the butt of the musket underneath the butt plate. The telemeter consists of a small



Le Boulengé rifle telemeter.

glass tube about $\frac{1}{8}$-inch diameter and 2.25 inches long graduated for 1,300 meters. It is inclosed in a slip of rubber tubing, cut out on the

Fig. 1.

Fig. 3.

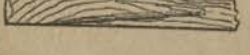


Fig. 2.

Fig. 4.

Fig. 5.

side, so that when stretched over the glass tube it will protect it from concussion, and yet permit a view of its contents. Price 90 cents.

The sketches here given exhibit the manner of holding the musket when using this instrument: 1, is the adjustment; 2, waiting for the flash; 3, position when the flash is observed; 4, position when the report is heard; 5, position assumed in taking the reading.

Major Le Boulengé also exhibits:

No. 1. Infantry telemeter, $2.28; good for 1,400 meters.

No. 2. Field telemeter, $3.30; good for 2,400 meters.

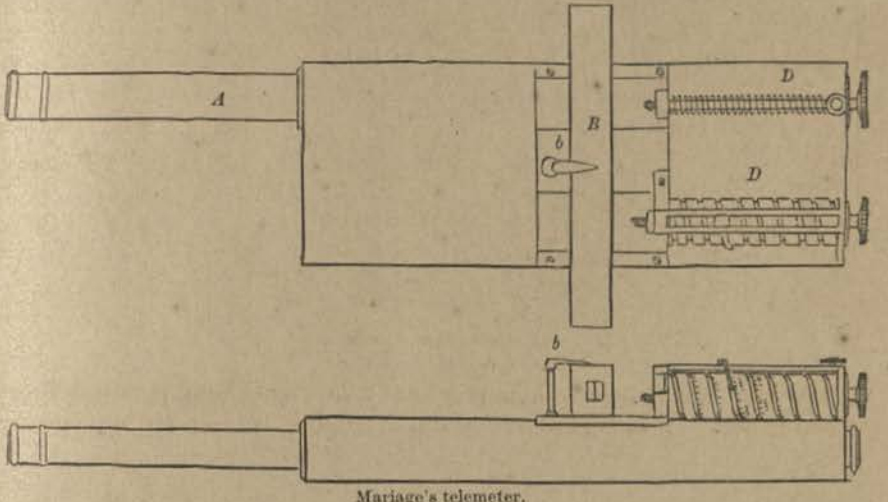
No. 3. Artillery, $4.30; good for 3,000 meters.

No. 4. Navy, $6; good for 4,000 meters.

No. 5. Garrison and sea coast, $9; good for 6,000 meters.

MARIAGE'S FRENCH TELEMETER.

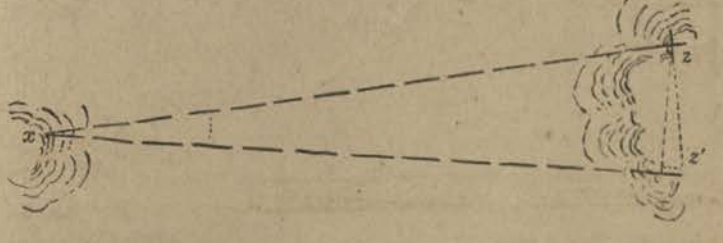
Consists of a black walnut block about 8 by 3½ by 1½ inches, in which slides a telescope A. This contains cross-hairs. By means of dowel



Mariage's telemeter.

pins on the upper surface of the block, a hollow square tube, B, may be placed directly at right angles to A. When set in place it is secured by the spring turn-buckle *b*. At each end of B is a fine vertical wire.

The instrument being placed in position, the object is sighted through

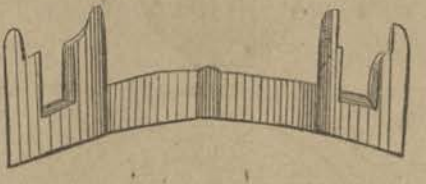


A. Then the observer passes around to B, and, looking through it by means of the vertical wire, stations his assistant at a point, *z*, exactly

40m to the right or left of *xy*. He then transfers the telemeter to *z*, leaving the relative position of the component parts unchanged. Sighting through A on *x*, the tube B is brought around by the screw D, to bear upon the point *y*. The angle *z' zy*, over which the tube B is caused to pass by this motion, is measured on the worm surrounding the body of the screw D, by means of an index, sliding in a groove above D' in the direction of its axis. Inasmuch as two elements of the triangle *xyz* are invariable, viz, *yz* and *xyz*, the worm can be gradnated so as to give the range *xy*, by simple inspection.

The accessories are as follows:

1. A copper wire cord exactly 40m long to measure the distance *yz*. This cord is divided by knots into four equal parts.



Stacking brace.

2. A stacking brace for forming a tripod as a support for the instrument. The middle curve of the brace incloses the stock of a rifle near its tip. The side notches are for the support of two other rifles pointing in opposite directions. They support the middle rifle in a vertical position. The block of walnut has on its lower surface a folding pivot which enters, friction tight, the muzzle of the middle rifle.

3. A black and white tin target about 4 by 3 inches, with a wooden stem to fit the bore of the service rifle. Used in sighting from *y* to *z*, and conversely.

4. A leather case about 8 by 4 by 2½ inches provided with loops around its greatest periphery, by which it may be slung on the shoulder.

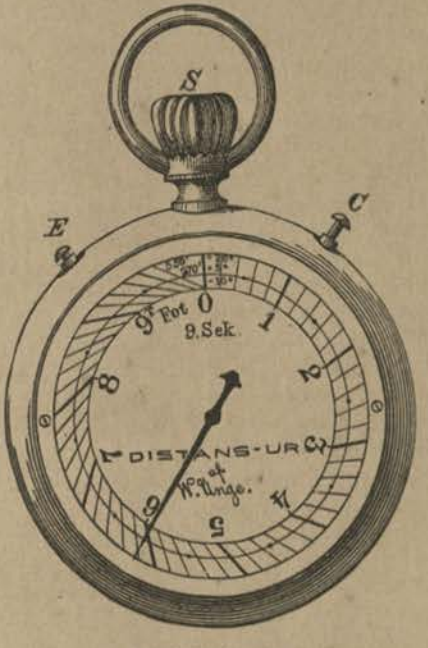
The knots on the base cord allow the instrument to be used for short distances, or where full 40m cannot be obtained for a base. The screw D allows a slight motion to be given to the tube B, to facilitate the adjustment of the target. It gives a variation of 2° on each side of the true position of *yz*. This gives an error which is inconsiderable in practice.

The instrument is good up to 3,000m, with a mean error of 1 per cent. A large size is prepared for batteries of artillery.

SWEDISH TELEMETER OR DISTANCE WATCH.

This instrument, like the Le Boulengé telemeter, depends for its construction upon the great difference between the velocity of light and that of sound. The watch is wound by the stem, S, but does not start until the button, C, is pressed down. This is done at the sight of the flash of the gun, the distance of which is to be estimated. The finger

is kept upon the button till the sound of the shot is heard. The index then indicates directly the distance of the gun. By touching the button, E, the index is brought back to zero. The index traverses the dial in 9.1 seconds, corresponding to 10,000 Swedish feet = 10,250 English feet. The inner circle is graduated for a temperature of 10° C. = 14° F. The other circles allow corections for temperature corresponding to 41° F. and 68° F. The figures 270′ and 550′, represent the number of feet by which the indicated distance is to be increased for every complete



Swedish telemeter.

revolution of the index. This instrument appears to possess several advantages over the Le Boulengé telemeter. Its operation is less complicated. It can be used for all distances without the risk of breakage to which the large Le Boulengé instruments are subject. It contains the means of correcting the observations for temperature, and appears free from the objections urged against the Le Boulengé in consequence of the errors due to any inclination of the instrument while in operation. It might profitably be used as an ordinary stop watch for getting the time of flight, &c., in which case the dial might have an independent subdivision into seconds. This would also allow of its correctness being verified by comparison.

CLASS H.—MISCELLANEOUS.

ASBESTOS FIBER.

The Asbestos Patent Fibre Company, Hope and Berk streets, Philadelphia, exhibit many specimens of asbestos fire-board, for coating steam-pipes and packing steam-joints. For this purpose the fiber is disintegrated and worked presumably like paper stock into light flexible board of any desired thickness. When woven into braid of circular or square cross-section it can be used for packing stuffing-boxes. The material is made into fire-proof paper for records, account books, &c.

KEELY'S SCREW-HEAD PAPER BARRELS.

The shell of the barrel is made by winding stout manila paper with pasted surfaces upon a mandrel of the proper size. In the operation screw-threads are compressed or molded near the two ends; corresponding threads are cut by machinery in the wooden heads, which can thus be screwed in without the use of tacks or screws.

N. Keely, Leverington, post-office Philadelphia.

ARCHES OF RAILROAD IRON (RUSSIAN).

Russia makes a striking use of old railroad iron to form roof and sides of buildings by bending it into semi-circular form, joining together

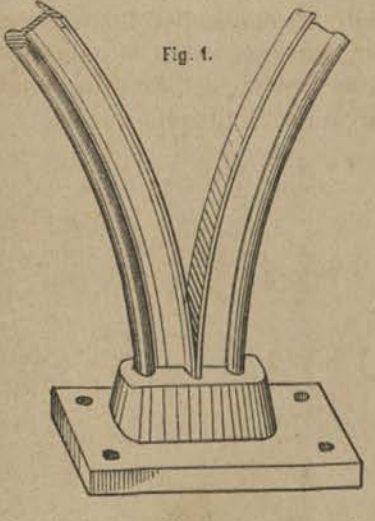


Fig. 1.

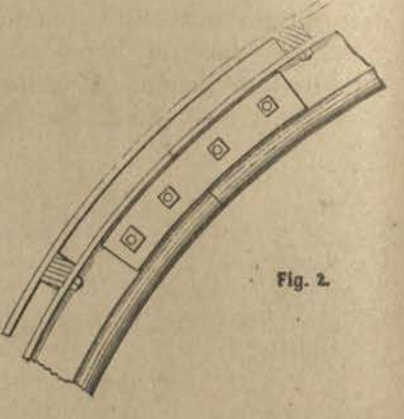


Fig. 2.

the ends of the rails by ordinary fish-bars, and riveting purlins between arches covered with corrugated iron roof. Each cylindrical set of arches is joined with the nearest parallel row by means of a horizontal

brace clamped to the feet of the rails in the manner represented in the sketch at A. This is covered with roofing as in the other portions of the structure.

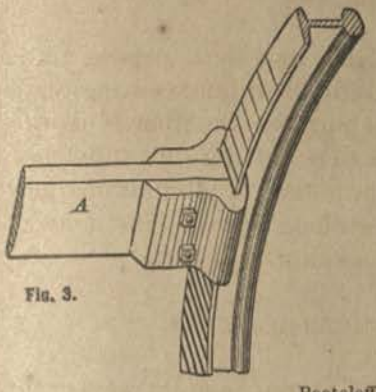


Fig. 3.

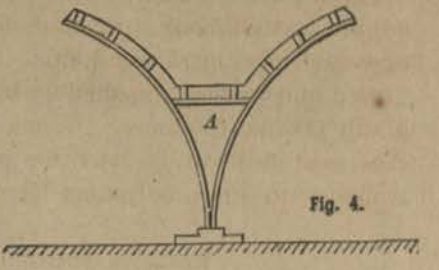


Fig. 4.

Pooteloff's arches of railroad iron.

VULCANIZED FIBER.

This consists of vegetable fiber reduced to a pulp, and then subjected to a peculiar treatment rendering it either hard or flexible as desired. The hard fiber is somewhat like horn in its consistency, is very tough and strong, and is said to remain permanently elastic under all ordinary conditions of weather and temperature. The soft fiber resembles sole-leather, and may be employed as a substitute for it or for rubber for packing. The vulcanized fiber has the property of expanding slightly in water, becoming elastic like leather thereby. It is said to be insoluble in hot and cold water, oil, naphtha, alcohol, and to be but slightly affected by the acids. Its use is especially recommended for washers, water-tight butt-joints, tongues, for light bearings being set edgewise in a brass box and bored out. Its specific gravity is 133, price about 30 cents per pound. Its color is generally a dull light red.

Office 17 Dey street, New York City.

THE SIGNAL SERVICE.

LIEUT. F. C. GRUGAN,

2D CAVALRY, A. S. O.,

IN CHARGE OF SIGNAL SECTION OF THE WAR DEPARTMENT PARTICIPATION IN THE EXHIBITION.

DESCRIPTIVE CATALOGUE

OF

ARTICLES EXHIBITED IN THE SIGNAL SECTION OF THE WAR DEPARTMENT EXHIBIT.

DIVISION OF TELEGRAMS AND REPORTS FOR THE BENEFIT OF COMMERCE AND AGRICULTURE.

The importance of self-recording instruments in furnishing continuous records of meteorological changes is now fully recognized.

Only those devised by members of the Signal Corps are exhibited. The wind-instruments and rain-gauges are in actual operation, being supplied by artificial currents of air and water. Specimens of the record-sheets, for examination, are exposed with each instrument.

1. *Anemograph* (velocity). Devised by Private A. Eccard, Signal Service, U. S. Army.

This instrument records the velocity of the wind in miles and tenths of miles. Wind-cups revolving on the roof close an electric circuit for every tenth of a mile. The closing of the armature causes a claw to catch in a pinion and to turn a cogged wheel, which, acting on a vertical screw, raises and lowers a pencil which makes its record on ruled blanks attached to two cylinders turned by clock-work. One cylinder holds the daily, the other the semi-monthly sheet. The screw is so compensated that when the carriage bearing the pencil travels from top to bottom, or vice versa, it indicates that fifteen miles of wind have passed. The vertical lines on the sheet give the time. The sheets are changed, one daily, the other semi-monthly.

2. *Rain-gauge.* Devised by Private A. Eccard, Signal Service, U. S. Army.

This instrument, mechanical in its action, records the amount of rain-fall and the moment of beginning and ending thereof during the twenty-four hours. The rain is collected in a funnel-shaped vessel on the roof of the observing station, conducted through a tube to the gauge, where it flows into a cylinder. In the latter a float is suspended, and as the water rises the float is carried with it. A light silk thread passes from the float over rollers and gives motion to a pencil, which, by traveling over the record-sheet, gives amount of rainfall and time. As the float rises the pencil sinks, and the figures on the sheet and corresponding lines give the amount of rainfall. The pencil is also connected with the clock-work which turns the cylinder bearing the record-sheet, and registers the amount of water in the gauge every four minutes. The sheet is changed daily.

3. *Anemograph* (direction). Devised by Private A. Eccard, Signal Service, U. S. Army.

This instrument records in a constant manner the direction of the wind as well as its veerings. An extended spindle passes from the wind-vane on the roof to the in-

strument. At the lower extremity of the spindle a cog-wheel is fastened. This wheel moves an endless screw, on which a pencil travels upward and downward, every shifting of the wind making a corresponding record on the sheet. The sheets are ruled so that the time of each change in the direction of the wind can be determined. On the ceiling of the room in which the instrument is placed is fixed a ring, bearing the points of the compass in legible letters; a small vane or arrow is attached to the spindle of the large vane, and indicates by the position of the the arrow the direction of the wind. The record sheet on the cylinder is changed daily.

4. *Anemograph.* Devised by Lieut. D. J. Gibbon, U. S. Army.

This instrument furnishes a record of the velocity or force of the wind. The self-register is connected by electrical wires with a Robinson anemometer, this latter consisting of four equal metallic cups in the form of hemispheres attached to the extremities of the arms, which cross each other at right angles, turning freely about a vertical axis. The action of the wind on the concave side of the cups is greater than its action on the convex side, so that a slight breeze is sufficient to make the cups rotate. The dials of anemometer are connected with the cups, and are graduated so as to indicate the miles or fractional parts of miles traveled by the wind. Two wires lead from an electrical battery through the register to the dial of the wind-cups exposed to the wind. These wires become a continuous wire only when a spring located in the dial is pressed down by pins fixed on the face of one of the dials at intervals equal to one mile of wind. The closing of this spring allows the electrical current to flow, the magnet attracts the armature in the self-register, which bears a pencil, and the pencil makes its mark on the paper. The cylinder in the register revolves by clock-work. The paper fixed thereon is so ruled as to show fractional parts of the twenty-four hours. The blanks are changed daily at 12 m. By counting the number of pencil marks the following data can be obtained: total number of miles of wind during the 24 hours, and variations in velocity of wind at any moment during the day or night.

5. *Anemograph.* Devised by Lieut. D. J. Gibbon, U. S. Army.

This instrument furnishes a record of the velocity or force of the wind for every mile and the direction of the wind at intervals of five minutes. The velocity is obtained as described in No. 4. The direction is obtained in the following manner: The N., S., E., and W. points of the wind-vane exposed to the action of the wind are connected each by a distinct wire to the self-register and to an electrical battery. The electrical circuit is closed or opened every five minutes by a contact-closer in the clock of the anemograph. If pointing to the north the north wire receives the electrical current, closing its armature, and bringing the hammer attached thereto upon the record-sheet on the cylinder.

6. *Rain-gauge.* Devised by Lieut D. J. Gibbon, U. S. Army.

This instrument has a funnel cylinder and float similar to No. —. A thread from the float passes over a roller to a lever bearing a small weight, the latter to keep a constant tension on the thread. As the float rises, the tension is lessened, the lever sinks, closes an electric contact, the armature of the magnet is attracted, and the circuit completed. To the armature is attached a long, vertical, toothed arm resting in a cogged wheel. When the armature is attracted, the extremity of the arm sinks into a cog of the wheel and turns the spiral, this latter being on the horizontal axis which supports the cogged wheel. The spiral travels across the surface of a sheet fastened to a cylinder turned by clock-work. Every closing of the circuit indicates $\frac{1}{100}$ of an inch of rainfall, the passing of the marker once across the sheet indicates that $\frac{1}{4}$ of an inch of rain has fallen. The time of beginning and ending of rain is also indicated by rulings on the paper. An escapement throws the armature from the magnet after each registration. The sheet is changed daily at 12 m.

7. *Evaporograph.* Devised by Private A. Eccard, Signal Service, U. S. Army.

This instrument consists of two parts: 1st, the vessel containing water conveniently exposed for determining the amount of evaporation, and electrically connected with the second part or recording apparatus, which may be placed in the observatory or at any distance from the point of exposure.

The vessel containing water is supported upon a float on mercury, and is also connected at its center with a lever, the extremity of which is balanced between two points, communicating with two electro-magnets of the recording apparatus. The fulcrum of the lever is operated in either direction by two additional electro-magnets, the circuits of which are closed by driving works.

The recording apparatus is provided with two rollers revolved by clock-work, one completing its revolution in twenty-four hours, the other in thirty-one days. Between the rollers is an upright screw, which moves the pencils downward, corresponding to the evaporation, or upward indicating the rain-fall. The screw carrying the pencil is operated by a double driving work.

When $\frac{1}{2000}$ of an inch of water is lost by evaporation the weight is sufficiently reduced to cause the lever to touch one of the contact points, thereby unlocking the gearing which moves the pencils to correspond with the amount of evaporation. At the same time the circuit is closed, and the lever is readjusted between the contact points. Each movement of the instrument corresponds to eight times the amount of evaporation, or 8 inches on the "blank" correspond to 1 inch of evaporation. As the variation in weight serves to operate this instrument, it may be used at any temperature, and for recording the amount of snow-fall, without the additional trouble of melting.

8. *Thermograph.* Devised for the Signal Service by W. Hough.

This instrument records the variations in temperature. A shelter contains the thermometer—a syphon-bent tube, the arms of unequal size, the larger containing alcohol, the smaller mercury. On the surface of the mercury rests a small ivory float, which, by means of a thread, is attached to a lever, both arms of which have platinum points. This lever is suspended over two small cups containing mercury. The mercury answers as a conducting medium for the electrical current. The two cups are connected by wires with magnets in the instrument. One armature answers for both magnets. If the temperature in falling causes the mercury to sink, the float goes with it, and the arm of the lever sinks into one of the cups containing mercury, completing an electric circuit. By means of the wires leading to the magnets, the armature is attracted to its respective magnet, moving a mechanism which, connected with a vertical screw, turns the latter. A pencil works on the screw-thread in a direction corresponding to the change in the position of the float (in this case downwards), and makes a constant record on the record-sheet fixed on a cylinder turned by clock-work. Another attachment prints the state of the thermometer hourly. Small type are fixed on rotary cogs, and any change in temperature will turn these cogs correspondingly. The record-sheet is carried slowly forward. An eccentric, affixed to the hour-wheel of a clock, causes a weight to fall on a padded lever, pressing the paper against the numbers on the cogs, and in this manner printing the state of the temperature at that time in degrees and tenths. The sheet for numerals is changed daily, the record-sheet semi-monthly.

9. *Barograph.* Devised by Private A. L. Foreman, Signal Service, United States Army.

This instrument is constructed on a plan similar to No. 9, with this difference, that the long arm of a lever is placed between two platinum contact points, and as the mercury rises or falls the upper or lower contact is touched and motion given to a series of cog-wheels, which raise or lower a pencil moving over record-sheets. The

sheets on the cylinders are changed, one daily, the other semi-monthly. An additional attachment consists of a heavy lever-shaped hammer, padded on one side, which hourly presses the record-sheet against type and prints a record of the hourly barometric reading. This sheet is carried forward by clock-work and is changed daily.

10. *Barograph.* Devised by Lieut. Henry Jackson, U. S. Army.

This instrument records the changes in atmospheric pressure, furnishing a constant record of the barometric condition. It is mechanical in the method of recording. A float resting on the surface of the mercury in the short open arm of the siphon-shaped tube is connected by a thread to one arm of a lever, on the other arm of which a pencil and counterpoise weight are fastened. If the atmospheric pressure increase, that is, if the barometer rise, the mercury in the short arm will sink, with it the float and the end of the lever bearing the pencil will rise and make its record on a record-sheet fastened to a cylinder turned by clock-work by means of mechanism which also connects the pencil with the clock, causing it to strike against the paper every four minutes. The record-sheet is changed daily.

11. *Barogroph.* Devised by Lieut. D. J. Gibbon, U. S. Army.

This instrument records the atmospheric changes by means of electricity. A float rests on the surface of the mercury, connects by a thread with one arm of the lever, the other arm of which is lengthened out for the purpose of multiplying the motion, and is, at its extremity, tipped with platinum. This end is suspended between two other platinum points, the latter connected with their respective magnets. If the float sink, the lever moving throws upward the long arm, touches the upper contact point, and completing an electric circuit, attracts an armature, and gives motion to a cogged wheel. This wheel, by means of other wheels, is attached to a vertical endless screw bearing a pencil which moves over the surface of two cylinders bearing the record-sheets, one of these furnishing a daily, the other a semi-monthly record, and in this manner gives an uninterrupted record of the barometric oscillations. It records a change in the barometer of .005 of an inch, and the lever is so mounted as to follow the vertical movement of the mercury, thereby allowing the float to rest freely on the mercury after each contact.

12. *Marine barograph.* Devised by Lieut. D. J. Gibbon, U. S. Army.

This instrument is similar to No. 1—excepting that the two columns of mercury communicate by means of a contracted opening 0.1 of an inch in diameter. This contraction, together with the manner of suspending the instrument upon a universal joint, serves to prevent the sudden movement of the vessel from destroying the equilibrium of the mercury.

13. *Printing press.*

For printing the "Farmers' Bulletin."

14. *Composing stone.*

15. *Type stand.*

16. *Map press.*

With changeable weather symbols, for printing the tri-daily War Department weather maps.

17. *Case.*

Containing steel stamps for the printing of stamped weather maps, printed and issued at stations not supplied with printing presses.

18. *Cipher book.*

Used in translating weather reports telegraphed tri-daily from Signal Service stations to the Washington office; also specimens of original and enciphered reports.

19. *Morse telegraph instruments.*

Instruments by which the tri-daily weather reports are received at the exhibition from the central office at Washington.

20. *Manifold bulletin.*

On this the weather reports are written after being deciphered.

21. *Weather map.*

Displayed in boards of trade and chambers of commerce, the disks and arrows showing the state of the weather and direction of the wind at the date of the report; the small tags showing, by the figures written on them, the humidity, the temperature, the barometric reading, and the velocity of the wind.

22. *Cautionary-signal indicator.*

Displayed in boards of trade, chambers of commerce, and pilot offices, to announce the approach of storms considered dangerous. The red ball is raised upon telegraphic order from the Chief Signal Officer.

23. *Cautionary-signal board.*

Displayed as above, and showing by name the ports and stations which are on the path of the storm announced as approaching by the Signal Office.

24. *Cautionary-signal flag.*

Displayed on stations to give notice of the approach of dangerous storms.

25. *Cautionary-signal lantern (red light).*

Used at night to announce the approach of storms.

26. *Instrument shelter.*

So arranged as to provide for a free circulation of air about the different meteorological instruments used at Signal-Service stations for obtaining the temperature and humidity of the air.

27. *Minimum thermometer.*

Shows, by the position of the index in the tube, the lowest temperature during the 24 hours.

28. *Maximum thermometer.*

Gives the highest temperature during the 24 hours. The mercury is forced over the small indentation near the bulb, and cannot return of itself. To adjust the thermometer the tube is revolved rapidly until the mercury reads the temperature of the air.

29. *Standard thermometer.*

Used on stations for obtaining the temperature of the air.

30. *Hygrometer.*

Two bulbs, one kept moist by water, which, by evaporating, gives a difference of reading between the two thermometers. From this difference the amount of moisture in the air is deduced.

31. *Barometer.*

Used on stations to ascertain the atmospheric pressure.

32. *Water thermometer.*

For finding the temperature of lakes and rivers.

33. *Rain-gauge.*

For measuring the amount of rainfall; measuring-stick for rain-gauge

34. *Robinson's anemometer.*

35. *Tool-box.*

Containing tools and supplies for repairing and cleaning meteorological instruments on station.

36. *Bulletin board.*

For the tri-daily weather reports received from the Signal-Service stations of the United States and Canada, and for the "synopsis and probabilities" issued by the chief office at Washington, D. C.

37. *Farmers' bulletin.*

Announcing the approaching weather; published for the benefit of commerce and agriculture.

38. *Publications of the Office of the Chief Signal-Officer, and works on meteorology.*

Used in the course of instruction at Fort Whipple, and on Signal-Service stations.

39. *Wind charts.*

Showing force, direction, and frequency of winds at the principal ports, cities, and stations of the United States; and meteorological maps compiled in the chief office.

40. *Weather quadrant maps of the United States.*

Showing winds most likely to be followed by rain or by dry weather, compiled for the Signal-Service stations.

41. *River-oscillation charts.*

Showing rise and fall of the rivers of the United States.

42. *Photographs of Signal-Service stations on Pike's Peak, Colo., and on Mount Washington, N. H.*

DIVISION OF FIELD SIGNALS.

The division of field signals comprises the different modes of communication adopted for the Army and Navy. It embraces: signaling with flags by day, and torches by night; by homographic code, chronosemic signals, semaphones, candle-bombs, rockets, colored fires, heliograph, &c., and communication by the military telegraph.

The signaling by flags and torches is made by the waving of the flag or torch to the right or left, the letters being formed by one or more motions either to the right or left, or both, words being spelled out, each letter of the alphabet having its signal. If the alphabet be already formed, as soon as intercourse between two signal lists is established the messages can be interchanged. Should there have been no alphabet preconcerted, or should a cipher alphabet be required, it can be formed in a short time by persons instructed in the signal system, though many

miles apart, provided they be in sight of each other. Messages have been sent by the signal code a distance of 10 miles with a pocket-handkerchief on a 12-foot pole. With the flags and staffs in use in the Signal Service of the Army communication has been had at 25 miles distance, the Signal Service field telescope being used.

The following apparatuses are used for signal purposes:

43. *Flags.*

The field equipment consists of three kinds of signal flags, white, red, or black, of three different sizes, 6 feet, 4 feet, or 2 feet; that color being used which is best suited to the background.

44. *Signal-staff.*

This consists of three joints, each 4 feet long, and fitted with ferrules to join to each other joint by joint. The second joint is tipped with brass, and is that to which the torch is attached for night signals.

45. *Torches (with flame shades and extinguishers).*

Two in number, flying-torch and foot-torch, to be supplied with wick and burning fluid.

The flying-torch, as its name implies, describes to the right or left of the central light, or foot-torch, motions similar to those made by flags, as previously described. Signals are legible at distances varying from 10 to 20 miles.

46. *Canteen.*

Containing supply of burning fluid for torches.

47. *Haversack.*

Containing articles used in trimming or filling torches.

48. *Canvas kit-cases.*

Containing the flags and torches, one case closed, one case open.

49. *Homographic disks.*

The relative positions obtained by extending the arms to the right or left of the body or above the head indicate a signal to be transmitted. (See p. 144, Myer's "Manual of Signals.")

50. *Bombs.*

Are pasteboard shells charged with brilliant stars and so fitted with fuzes that they can be thrown into the air and exploded at a great height. They afford very distinct and marked signals. When prepared for use there is attached to them an ordinary cartridge of powder filled with a long match. They are fired from bomb guns or mortars.

51. *Mortars.*

Consist of hollow cylinders formed of thick pasteboard, sole-leather, or sheet copper, 2 or 3 feet in length, of sufficient diameter to readily admit the bomb, and closed at one end by a block of wood or a plate of some metal.

52. *Colored lights and fires with Signal-Service pistol.*

The use of colored lights for signaling purposes has become quite extended, being employed both by the Army and Navy. The system of communication by these colored lights is based upon the meanings conveyed by an exhibition of different colored

flames or lanterns such as show *single* colors, *white*, *red*, or *green*, or *double* and *triple* consecutive colors, *white-red* or *white-red-green*, &c. Between ships at sea in cases of distress or during a war, great difficulty is at times experienced in exchanging messages at night and the light signals were devised to remedy this defect.

53. *Signal-Service rockets.*

Used for communicating messages by night. They are specially adapted to the chronosemic system, based upon certain intervals of time being allowed to elapse between the explosions of successive rockets. These are regulated by correctly timed fuzes. (See page 164, Manual of Signals, U. S. Army.)

54. *Field heliograph and sighting rod.*

For transmitting messages by sun-flashes. This instrument transmits signals to great distances. Heliograph signals can be read with the naked eye a distance of 20 miles or more.

55. *Heliograph for permanent work.*

56. *Model of portable telescopic elevating tower, with its wagon.*

57. *Portable telescopic elevating tower and wagon.*

Devised by J. W. Davis, of Washington, D. C., giving an elevation of 75 feet, weight 1,350 pounds. To be used for signal purposes with troops in the field.

58. *Model of United States field telegraph train.*

59. *Signal-Service telescope.*

60. *Signal-Service field glass.*

61. *Signal-Service telescope holder.*

62. *Flying torch and staff fitted for use.*

63. *Flag (4 feet) and staff fitted for use.*

64. *Rocket stand for firing rockets.*

65. *International signals.*

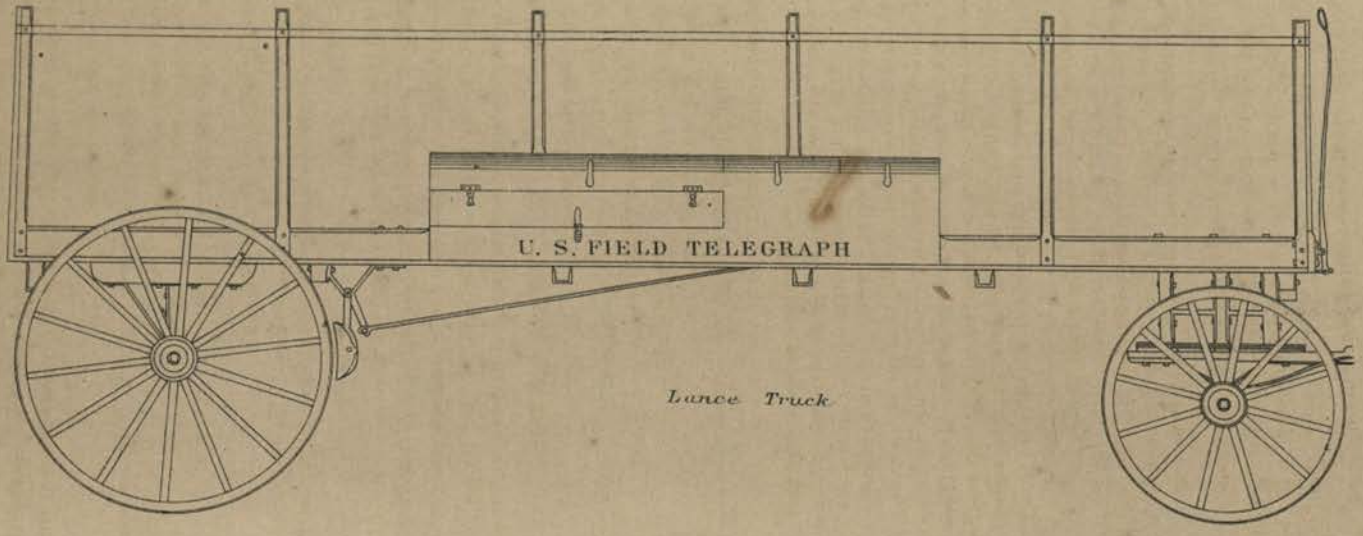
This code was prepared by a committee appointed by the British Board of Trade to inquire into and report upon the subject of a code of signals used for communication at sea. It is known as the International Signal Code, and has been generally adopted throughout the world. When once fully adopted it will be a universal method of intercourse. Its symbols consist of eighteen flags, namely: 1 burgee, 4 pennants, and 13 square flags, representing the eighteen consonant letters of the alphabet which are used as index letters of the code. There is also, in addition, a code pennant which is used as "code" signal and "answering" signal. The flags are hoisted in combinations of two, three, or four, according to the number of possible combinations thus obtainable. Each different from the other, is 78,642. The international code, as its name implies, has been so framed as to be capable of adaptation for international communication, all such words and sentences as can ordinarily be required for any purpose being comprised within its limits. It was adopted in 1873 by the Signal-Service stations established in connection with life-saving stations on the Atlantic coast and Gulf of Mexico. (See "International Code of Signals," published by the Bureau of Navigation, U. S. Navy Department.)

66. *Fac-simile, or autographic telegraph instruments.*

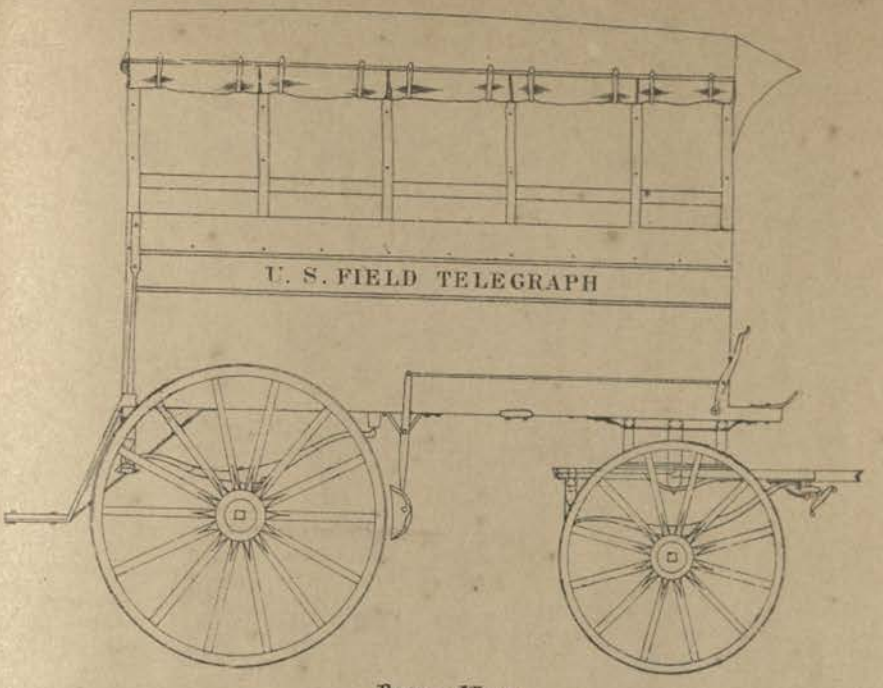
By this the War Department weather maps, issued at the Signal Office, at Washington, D. C., are received by telegraph for publication in the New York Herald. See description at pages 981, *et seq.*

67. *Field telegraph train, United States Army.*

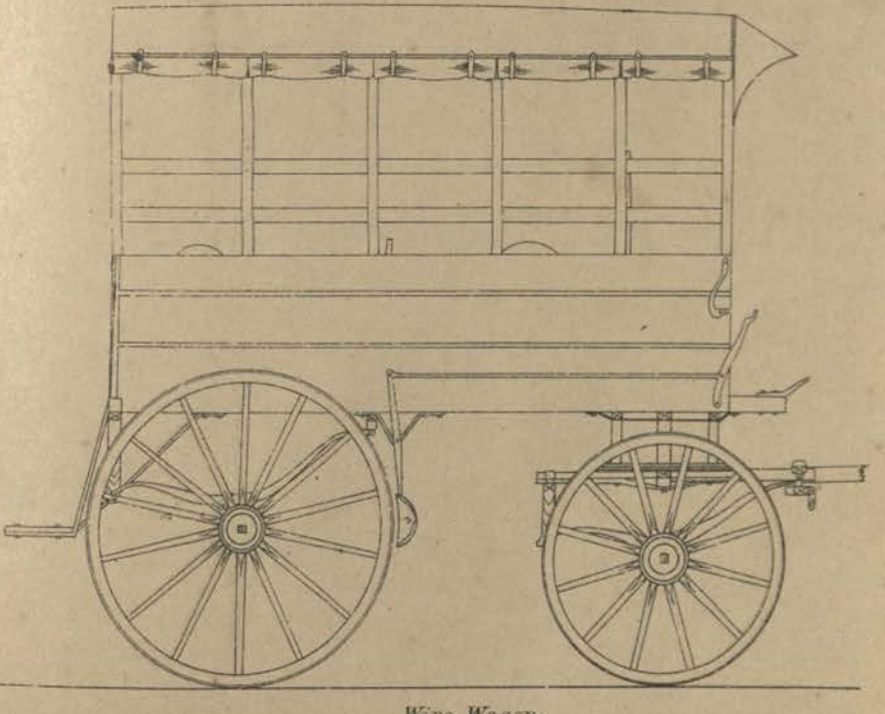
Organization for an Army corps. A train consists of: 1 battery-wagon, 4 wire-wagons, and 4 lance-trucks. It will be divided into four sections, each commanded by a lieu-



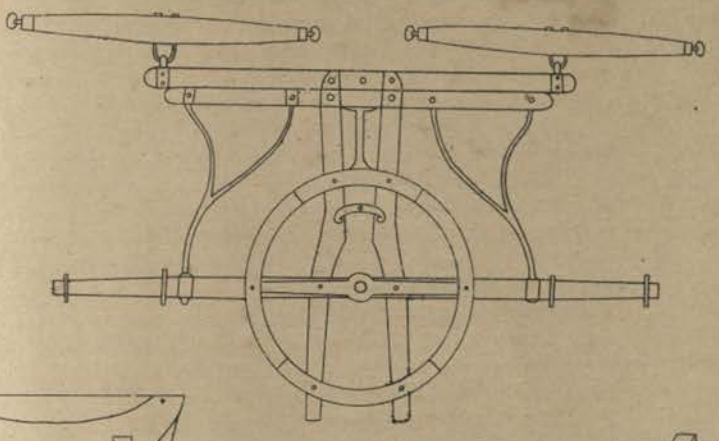
Lance Truck



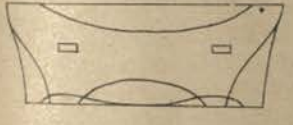
Battery Wagon.



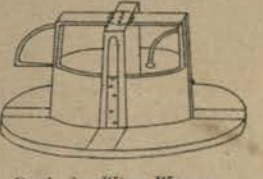
Wire Wagon



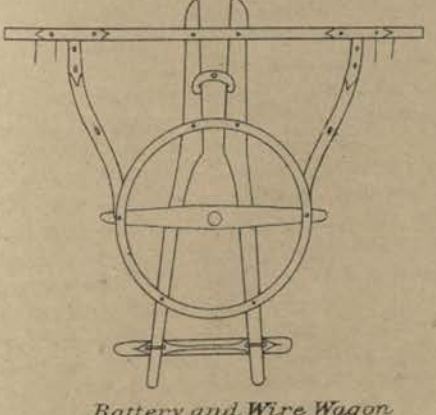
Lance Wagon



Front view of Top bars



Reel for Wire Wagon



Battery and Wire Wagon

tenant, the train being commanded by a captain. Each section will consist of: 1 wire-wagon, and 1 lance-truck.

The *battery-wagon* is the central or headquarters office—from which four lines may be worked—contains four tables attached to the sides by hinges, one table in each corner of the wagon, and four camp-stools. The batteries, in sections or cases of six cells, are supported by brackets underneath the tables, each bracket supporting two sections. The instruments, when not in use, are carried in a box underneath the driver's seat, together with a supply of stationery, of battery material, pliers, &c. A stove is placed in the center of the floor and secured against displacement. The wagon is mounted on platform springs, turns in its own length, is covered with canvas, is entered by a door at the rear, and is drawn by two horses.

The *wire-wagon* is of the same general form as the battery-wagon. An instrument table is attached to the front end, a single section of battery underneath the table, a camp-stool for operator, a wire-reel seated in a socket in the center of the floor, near the hind end; a hand bearer secured at the top of the wagon by straps, ten coils of wire (one mile in each), secured to the sides of the wagon. Pliers, files, connectors, instruments, &c., are carried in the box underneath the driver's seat.

The *lance-truck* is a wagon without springs, of length sufficient to carry lances, and of strength sufficient to sustain the weight of from 300 to 500 lances, and all the line tools and insulators for 10 miles of line. The lances are stowed compactly in the middle of the wagon or truck. The insulators and tools are contained in boxes arranged for the purpose on either side of the wagon (external).

The arrangement of sections allows independent action for each section. Thus a full train may erect lines radiating in four directions from the battery-wagon, or the four sections, the second commencing to reel out its wire when the first has finished, may extend a single line 40 miles long, or more, having offices at the termini and at three intermediate points equidistant from each other. Additional instruments being furnished, intermediate offices, other than the regular ones, can be opened whenever necessary.

The force required to work the whole train is 5 commissioned officers and 174 men. Each section (wire-wagon and lance-truck) requires 1 lieutenant and 40 enlisted men, distributed as follows: One lieutenant in charge of section; 1 director and 2 markers, whose duty is to indicate the route of the line of wire to be erected; 1 surveyor, who follows along the line indicated by the markers and points out the places where the lances are to be erected; 3 pinmen, the first and second of whom accompany the surveyor and place marking-pins at the points indicated by him; the third pinman gathers the pins as the line is erected; 13 bar-men (one being a non-commissioned officer and in charge), who, armed with crow-bars, make holes large enough to receive the lances at the places marked by the pins; 2 wire-men, who have charge of the handling of the wire when reeling out and reeling up; 3 operators, who accompany the wire-wagon; 13 lancemen (one a non-commissioned officer in charge), 2 of whom ride on the lance-truck, and, attaching spikes and insulators to the lances, pass out a lance at each point indicated by a marking-pin; the remaining 11 follow the wire-wagon and erect the line on the lances; 1 driver for the lance-truck; 1 driver for the wire-wagon. The force required for the battery-wagon providing for lines will be 1 driver, 12 operators, and 1 battery-man. The duty of the latter is to take charge of the batteries and other material contained in the battery-wagon.

The messages are received by sound. The instrument used is the "box-sounder," and also what is known as the Caton instrument, 6 inches long and 2½ inches in width and height. The alphabet used in the *field telegraph* of the Signal Service is the "General Service Code" of the Army and Navy.

The materials for a line of field-telegraph (by which is meant a line to be used in the presence of an enemy, and for the purpose of placing the commanding officer of a force in constant communication with all parts of his line) differ from those for permanent lines chiefly in point of size and capability of being quickly erected and put

into use, and as quickly removed when the occasion for the line no longer exists. These materials must be, therefore, such as can be transported with the troops, handled by enlisted men, and, when in line, worked by enlisted men or officers.

The artificial supports must be of such size and weight as may be transported, and at the same time have length sufficient to carry the wire above the reach of mounted men or wagons, and strength enough to endure such handling as under the circumstances they would be likely to receive, as well as to bear the weight and strain of the line-wire. To meet these requirements they must be made of a material at once light and elastic, and the timber best adapted seems to be spruce or cypress, either of which, when well seasoned, fulfills very nearly these conditions. The size may vary within certain limits, but that adopted in the field telegraph trains of the United States Army is 17 feet long, 2½ inches diameter at the butt, and 1½ inches diameter at top, the butt tapering to a blunt point and the top secured by a sheet-iron ferrule 3 inches in length. Such a lance, of cypress, weighs about 11 pounds, and of spruce a trifle less. A field-line should be supported by forty such lances to each mile of wire, but in emergency, or upon favorable ground, this number may be reduced to thirty-five or even to thirty without serious difficulty resulting.

The insulators are made of what is known as "ebonite," a prepared form of caoutchouc, cap shaped, and armed with a gimlet-pointed screw, by which they are fastened to the lance or to natural supports, such as trees, houses, &c. The ebonite caps have either a cleft in which the wire rests, or a curved clamp around the arms of which the wire is passed. The swinging insulator is also in use.

Wire for field telegraphs must be light, flexible, and strong enough to bear a tension which will reduce the deflection or "sag" between lances 70 yards apart of 2 feet. Iron is the only material which answers the purpose at moderate cost, and an iron wire, drawn from charcoal rods to No. 15, American gauge, has been adopted for use by the United States. A mile of this wire, joined up and the joints soldered, makes a coil 18 inches in diameter inside, 4 inches in height, and 3 in thickness, and weighing but 75 pounds. A supply of insulated wire, or cable, is also carried with each wire-wagon and with the battery-wagon.

The tools for the erection of a field-line (which constitute, with the materials for the line, the outfit for the train) are: Marking pins, by which the points of support are indicated; axes and hatchets, to cut away shrubs or branches of trees, or to affix insulators to natural supports; crow-bars, to make holes in the earth in which to set the lances; bars, fitted for cutting through frozen ground; climbers, to enable the men engaged in the work to ascend trees, when necessary, for the purpose of affixing insulators thereto or to trim away branches; reels, for the delivery and recovery (uncoiling and recoiling) of the wire; pliers, to be used in making connections; files and screw connectors, which are to be used for making connections between the coils (mile lengths) of wire in reeling out, and generally, where connections are to be frequently made and broken, to avoid loss of time and waste of wire.

The marking-pins are of iron wire, ¼ inch in diameter and 15 inches long, pointed at one end and having a loop or handle at the other, painted of some bright color, and fitted with a small pennon of bright-colored cloth, so as to be conspicuous objects, and are used to mark the places where lances are to be erected by being thrust into the earth at such points, or the natural supports to which insulators should be affixed by the same methods.

It is scarcely necessary to describe axes or hatchets, except, perhaps, to say that the latter should have a hammer-poll with which to drive a spike. But the efficiency of the line may depend on their use, which is mainly to cut down all shrubs growing near the line-wire, to trim off such as come, or might be thrown by the wind, in contact with the line-wire.

Crow-bars, with which to make seats for the lances, are cylindrical iron bars, 4½ feet long, 1¼ inches in diameter for 2 feet from the point, and 1 inch in diameter for the rest of their length, and pointed so as to penetrate the earth easily. Such a bar

weighs 15 pounds. These (and all the iron used in the work) should be zinc-coated (galvanized).

Ice-bars are of the same general form and dimensions as the crow-bars, but have a wide, chisel-shaped point or blade, and are used for cutting through frozen ground, to facilitate the work of setting the lances.

Climbers, to enable the men engaged in erecting a line to ascend trees to affix insulators and attach the wire, are of steel, with leathern straps, and weigh about 4 pounds the pair.

Reels for field use are in general form like those for permanent lines, but are lighter, and are provided with arms attached to the uprights, which are laid flush with the face of the uprights when reeling out wire, and secured at right angles thereto when reeling up, in order to confine the wire and give the coil its proper shape. Each one has a handle affixed to the extremity of one of the upper cross-arms, by which it is turned when reeling up wire.

The reel is seated in the wire-wagon, but may be carried by men over ground impracticable for the wagons in the hand-bearer, one of which should accompany each reel.

The battery is a sulphate of copper battery. It consists of a vessel made of sheet-lead, in the bottom of which is placed 3 pounds of sulphate of copper. This is covered with a layer of sawdust 1 or 2 inches thick, upon which a zinc plate rests. The vessel is then filled with water. This battery will give a strong and uniform current for a period of from three to six months without any attention whatever, care being taken to keep the cells filled with water. Each battery box contains six small size cells.

In the United States Signal Service a regular form of field telegraph drill has been adopted. The school of instruction is located at Fort Whipple, Virginia, 2 miles distant from the city of Washington, D. C.

68. *Battery-wagon, United States field-telegraph train.*
69. *Wire-wagon, United States field-telegraph train.*
70. *Lance-truck, United States field-telegraph train.*
71. *Lances, upon which the wire used in the field-telegraph train is placed.*
72. *Specimens of different insulators used in the field-train.*
73. *Field-batteries of the United States field-telegraph train.*
74. *Tools used in erecting the military field-telegraph lines.*

REPORT

UPON

THE SIGNAL-SERVICE SECTION OF THE WAR DEPARTMENT EXHIBIT.

By First Lieut. F. C. GRUGAN, 2d Cavalry, *Acting Signal-Officer.*

The following report is submitted upon the Signal-Service Section of the Army at the International Exhibition, which opened at Philadelphia, Pa., on the 10th May, and closed on the 10th November, 1876. The exhibit was made in compliance with the following order:

[Special Orders No. 192.—Extract.]

OFFICE OF THE CHIEF SIGNAL-OFFICER,
Washington, D. C., November 20, 1875.

* * * * * * * *

3. In compliance with the directions received from the Secretary of War, First Lieut. F. C. Grugan, Second Cavalry, and acting signal officer, is hereby assigned to the duty of collecting, arranging, and displaying at the International Exhibition o 1876, subject to the direction of the chairman of the Board on behalf of the United States Executive Departments, such stores, materials, and articles pertaining to the Signal Service, U. S. A., as shall be designated by the Chief Signal-Officer to be placed on exhibition. Lieutenant Grugan will report by letter, through this office, to Maj. S. C. Lyford, Ordnance Department, U. S. A., chairman of the above-mentioned Board, and representative of the War Department, for the necessary information.

By order of the Chief Signal-Officer of the Army:

GARRICK MALLERY,
Captain First Infantry, Bvt. Lieut. Col., U. S. A.,
Acting Signal-Officer and Assistant.

Upon the receipt of the order steps were at once taken to collect such Signal-Service materials as could be obtained and kept in working order during the exhibition, without exceeding the sum assigned to the Signal Service for the purpose of defraying all expenses connected therewith. The smallness of this amount, taken in connection with the limited space that could be furnished in the United States Government building, and with the small working force of enlisted men that could be spared from other duties, made it evident that much that would be of interest and instructive to the public at large would need to be omitted. It was finally determined to limit the display to an exhi-

bition of such signal apparatus as was used in the service for the purpose of maintaining communication between bodies of troops in the field, and to establish in the "Government Building" a Signal-Service station in practical operation similar to the stations located throughout the United States.

In the department of military signaling, the display consisted in the regulation equipments and supplies for day and night signals, such as flags, torches, bombs, colored lights, rockets, and heliographs, together with a military field telegraph-train fully equipped, with its telegraph line in actual operation.

In the meteorological department were exhibited the ordinary station instruments, a full set of the publications of the Signal Office, and a working station illustrating the printing of the weather maps and bulletins, the issuing and posting of bulletins, receiving and transmitting telegraphic weather reports, and such other duties as are usual at a station of observation. Only such self-registering meteorological instruments as were designed by the officers and enlisted men of the Signal Service were exhibited in the section, and, in order that they might be seen and examined in actual operation, they were placed under a roof of glass, and were supplied with artificial currents of air and water (rain), which, for each instrument and by means of stop-cocks, could be turned on or off at will. Every self-registering instrument, if an electrical one, was furnished with its own battery, and, whether electrical or mechanical in its action, was supplied with its respective wind-vane or anemometer, rain or snow gauge, located upon the artificial roof. With all were exposed specimen sheets of the records obtained.

The working force consisted of four sergeants and three privates of the Signal Corps. In compliance with the verbal instructions of the Chief Signal-Officer every effort was made to render the Signal-Service exhibit an instructive one to the general public. The Centennial Station was connected by telegraph with the chief office at Washington, D. C., whence were forwarded by telegraph the daily weather reports received from the numerous stations of the country. Daily bulletins, farmers' bulletins, river reports, and weather maps were printed, posted in the different buildings and throughout the grounds, and distributed to the public. Explanations were given of the workings of the service and of the meteorological instruments, and special efforts were made to call public attention to the practical use of the weather reports and maps, which last-named work was greatly assisted by the numerous copies of circulars on meteorological subjects and weather maps sent from the chief office for general distribution.

In connection with the meteorological work of the Signal Service of the Army at the International Exhibition, there was inaugurated a system of transmission of meteorological data, which, opening as it does a wide field for the every-day use of practical meteorology, will in time assist in solving many of the difficulties that are now met with in the exchange of weather reports.

The "forecasts" or "probabilities" issued by the central office at Washington, are based upon the tri-daily weather charts, and directly upon the location thereon of the lines of equal atmospheric pressure and equal temperature. The telegraphic reports from the different stations throughout the country determine the position of these lines upon the weather map, and the ordinary reader may, with little study, be able to arrive at fair conclusions as to the weather changes likely to happen; and the importance of being able to lay before the agricultural and commercial people of the United States at the very earliest practicable moment data regarding the anticipated atmospheric changes speaks for itself. In the Centennial edition of the New York Herald, printed daily in Machinery Hall at the Exhibition, appeared under the date of October 13, 1876, a fac-simile copy of the weather map of that day, issued by the central office at Washington two and a half hours previous to the printing of the Herald, and from that date until the close of the exhibition the electric telegraph enabled the Signal-Service weather map to appear in the daily issues of the Herald. These fac-simile maps showed the positions of the isobarometric and isothermal lines previously referred to.

The instruments designed for the purpose were designated fac-simile or autographic telegraph, and were the joint invention of W. E. Sawyer, of New York, and James G. Smith, of New Jersey. The motive power consisted of an electro-motor, worked by six cups of nitro-chromic battery. The map or sketch to be transmitted was drawn on ordinary paper, a special ink being used. Powdered shellac was then scattered over the writing, and the impression transferred to a thin plate of heated zinc by being pressed between pressure rollers, the shellac lines forming an insulating surface upon the conducting surface of the zinc. The process of transfer occupied about four seconds. The zinc was then placed upon a cylinder, which revolved rapidly under a metallic point, to which a lateral motion was imparted by the working of the instrument. This metallic point was connected with the main battery. The point in its side movement, drawing a fine imaginary spiral line as the cylinder revolved, passed over the entire surface of the zinc plate, the current flowing through the transmitter when the zinc and needle points were in contact, but being interrupted whenever the insulating surface of shellac was reached. When the former took place, that is, when the metallic point and zinc were in contact, the current passing to ground through the sending instrument, no flow of electricity reached the receiving station. When the reverse occurred, that is, when the metallic point came in contact with the insulating surface, a resistance was formed which threw the current out onto the line and through the receiving instrument at the terminal station. This latter instrument was similar to the transmitting one, its cylinder bearing, in place of the zinc plate, a sheet of chemically-prepared paper, the solution in which it had been immersed being decomposed by the electric current as it flowed

over the line, through the steel point of the receiving instrument and to ground. The decomposition discolored the paper. The movements of the two cylinders and of the pen points were simultaneous. The isochronous revolutions of the cylinders were secured by electro-magnetic clutches on the revolving shafts that bore the cylinders, each clutch passing the poles of a fixed electro-magnet with every revolution. The magnets, therefore, acted as speed regulators worked by a common current. In order to obtain a current of tension, small cells of carbon battery were used.

The size of the transfer blank was 5 by 5 inches. The ordinary speed of the instrument was ninety revolutions per minute. A surface of writing covering 1 by 5 inches was transmitted by sixty revolutions of the cylinder.

The weather map having been charted at the central office, the isobaric and isothermal lines were at once reduced in size, transferred to the zinc plate, and telegraphed to the signal office at the exhibition. There they were rapidly transferred to a base map of plaster and turned over to the Herald officials. From the plaster cast the required metal casting was obtained.

By referring to Fig. 1, it will be seen that A and B are the batteries; battery A, with negative pole to the line, doing marking on Philadelphia cylinder; battery B, with positive pole to the pen (P), neutralizing in the line the charge of battery A. R R are artificial lines or rheostats, exceeding in resistance the resistance of the line wire. The object of the resistances is to throw both batteries into the line by preventing them from short-circuiting. Battery A may be said to be always in the line, but, as long as the pen bears on the zinc plate around the cylinder, its action is neutralized by battery B. As soon, however, as the pen touches a line of writing (shellac, an insulating substance), battery B can no longer get into the line, and the pen of the receiver, supplied by the current from A, makes a mark upon the chemically-prepared paper on its cylinder. The arrows indicate the directions in which the pens and cylinders move. It will be observed that the receiving pen at Philadelphia works in a direction opposite to the pen of the transmitter. The original message being reversed upon the zinc plate, it becomes necessary to reverse the action of the Philadelphia pen in order to bring out the fac-simile as it should be.

Before proceeding further, it may not be amiss to state that it was originally intended to submit a report upon the exhibit of the Signal Service of the Army in its relations to similar exhibits made by foreign countries at the International Exhibition of 1876, but that a comparative report of the service as organized, equipped, and practically carried into effect in the United States and abroad is rendered impossible by the failure of foreign Governments to have represented at the exhibition this branch of their military and naval services—a failure which is the more to be regretted on account of the numerous experiments and im-

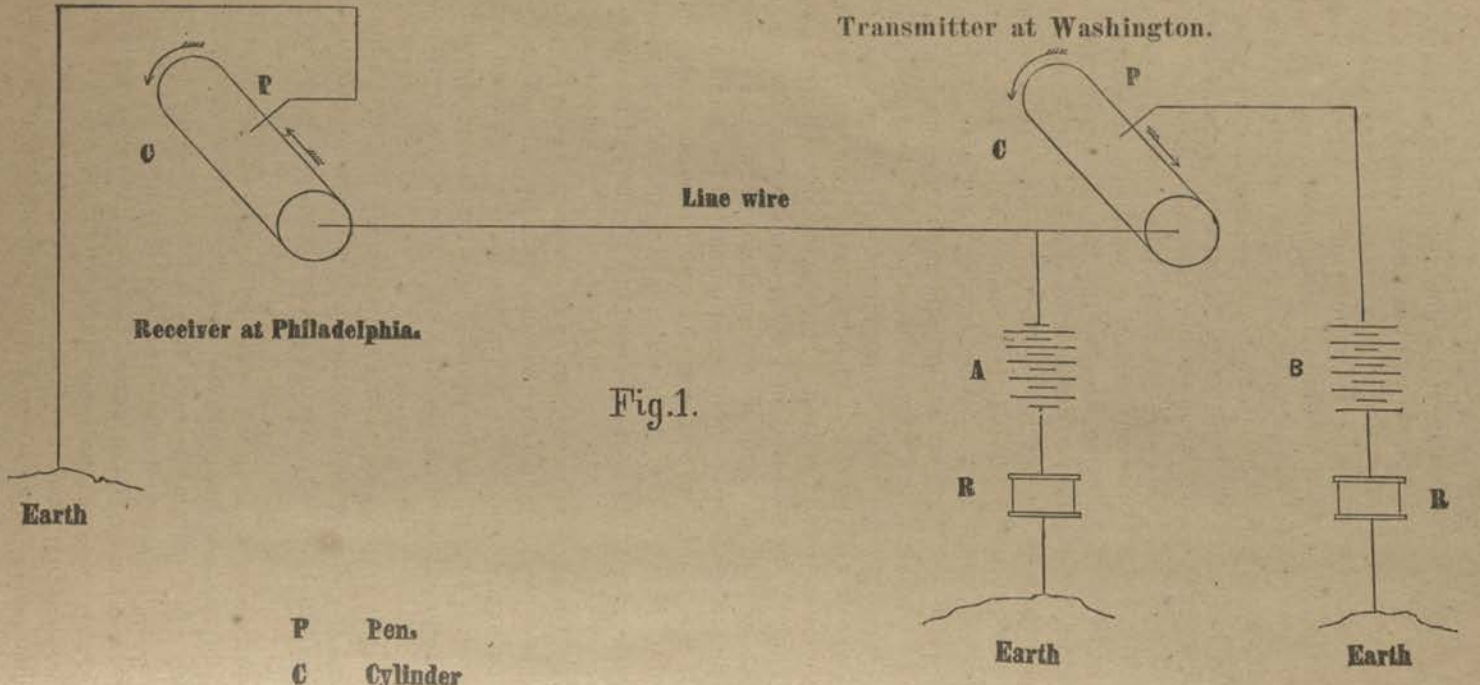


Fig.1.

P Pen.

C Cylinder

provements made in Europe in late years, and especially since the Franco-Prussian war, in military signaling and signal apparatus. The importance of the electric telegraph in successfully conducting military operations has become a recognized fact. No sooner had its superiority over all other means of communication become apparent than many prominent scientific officers in Europe devoted their attention to securing a disciplined, well-organized, and well-drilled corps, equipped with the latest and most approved apparatus. In the camps of instruction in Switzerland, and in the Austrian camp of Lintz, experiments were made as far back as 1854. In the Crimean war telegraph lines were established by the French and English commanders, and in the East Indies during the Sepoy rebellion of 1857 excellent service was rendered by the system of field electric telegraph, which had been introduced in the English army. In 1859 Prussia formed her first organization, and has, since that date, paid constant attention to the application of the electric telegraph for military operations, successfully altering her system as each campaign showed wherein it was inadequate. In France for many years much opposition appears to have existed to the formation of any regular military telegraphic organization. Field-telegraph lines were constructed during the late wars in which the country has been engaged, but her organization was not a military one, and when severely tested proved faulty. Depending upon civilian labor to work the lines and upon the peasants to build them, when danger came it too often happened that the workmen disappeared. Failure forced the abandonment of this mixed system, and France adopted a military organization, the practical working of which is being tested in autumn maneuvers in a camp specially set apart for field-telegraph experiments. In Austria, Belgium, Italy, Russia, and throughout Germany, the necessity for some regular organization has been recognized by the formation of special detachments, whose duties pertain to all that relates to field signals.

Various systems and instruments for day and night signals independent of the telegraph, and for use in the field, or in fortresses or standing camps, have been devised, experimented with, and adopted; and, at the present time, in several of the principal armies of Europe, experiments are being made in order to determine to what extent optical signaling can be depended upon on the actual field of battle.

In the United States no regular organization existed prior to the war of the rebellion. In 1860 Maj. A. J. Myer was appointed Chief Signal-Officer of the Army, and experiments were conducted by him for the purpose of devising a system of communication suitable for troops in the field. Upon the commencement of hostilities in 1861, the formation of what was known as the "Signal Corps of the Army" was carried into effect pursuant to orders issued by the Secretary of War. In 1863 Congress authorized the formation of a regular organization to exist only during the war. With the disbandment of the volunteer forces

occurred the muster out of this corps. In 1866 a reorganization of the Army was ordered, which provided for the office of "Chief Signal Officer of the Army, with the rank of colonel." Finally, in 1870, a reorganization of the Signal Service itself resulted in the formation of two branches or divisions:

Division of field signals.

Division of telegrams and reports for the benefit of commerce and agriculture.

Bvt. Brig. Gen. Albert J. Myer remained at the head of the organization as Chief Signal-Officer of the Army and 50 sergeants, 30 corporals, and 270 privates constitute the working force of this branch of the service. The officers required are obtained by details from the regiments of the line, the number (including those under instruction) averaging 14 lieutenants.

The division of field signals comprises whatever relates to field signaling proper. At the School of Instruction at Fort Whipple, Va., officers and enlisted men are exercised in the system adopted for use in the Army. Telegraph train drills and signaling with the different instruments devised for day and night service continue during the course of instruction. From the detachment at the school are drawn the working parties needed in constructing and maintaining the military telegraph lines on the coast or in the interior of the country, as also for duty at the life saving stations of the Northern Lakes and the Atlantic seaboard.

The division of telegrams and reports for the benefit of commerce and agriculture comprises all that relates to the meteorological work of the Signal Service.

The importance of regular meteorological reports was early recognized in this country, for the Medical Department, United States Army, commenced taking observations in 1819. The States of New York, Pennsylvania, and Ohio followed in 1825, 1837, and 1842, respectively, and the Smithsonian reports in 1849. These observations, while valuable to the scientific world as studies for future application, or in reference to the sanitary condition of the localities, were at first of no immediate benefit, and it was only when the introduction of the telegraph made their rapid transmission possible, that attention was drawn to the possibility of practical storm warnings. In 1857 the Smithsonian Institution in Washington was in the daily receipt of weather telegrams, transmitted gratuitously by the telegraph companies, from various places east of the Mississippi and as far north as New York, and published in the Washington Evening Star. In 1858, a map was hung up in the Institution, on which was shown daily the changes of weather reported by telegraph from different parts of the country. Reference was frequently made by Professor Henry and the able correspondents of the institution to the practicability of more extended plans of this description. In the same year, the American Association for the Advancement of Science

appointed a committee for the organization of a national system of meteorological observations, and a plan was presented, which provided for the appointment of a superintendent in each State, who was to collect and collate all observations within its boundaries, and forward them monthly to Washington. The expense of maintaining such a system was to be borne by the different States. No action was taken in the matter, however, and the daily publication of reports at the Smithsonian continued until the breaking out of the war in 1861, when it was suspended, but renewed again temporarily in 1862; but finally discontinued, owing to the cessation of observations in the south and southwest, and the constant use by the Government of the telegraph lines. In 1863, the newly appointed Commissioner of Agriculture commenced the monthly publication of a bulletin, giving the state of the weather and condition of the crops throughout the country from data furnished by correspondents. This publication is still continued, and is of value to the agricultural interests of the country. In 1869 a daily bulletin of the weather was published for three months in Cincinnati, Ohio, under the direction of Prof. Cleveland Abbe, and the experiment proved so successful that it was renewed.

Since 1863 several persons have endeavored to get Congressional assistance in organizing the national system suggested by the association in 1858. Mr. A. Watson, of Washington, has been earnest in advocating in the papers a system of storm signals for the benefit of agriculture.

Prof. J. A. Lapham, LL. D., of Milwaukee, has been a persistent and successful advocate of the importance of some national system of weather reports, in which the telegraph was to play an important part, and he brought powerful arguments to bear in the shape of statistics, showing the loss of shipping on our lakes alone for a series of years. His views were brought strongly to the notice of Congress in 1879, in a memorial replete with interest. By a coincidence, papers and maps in reference to the same subject were prepared in the War Department at the time the memorial was submitted.

The matter was finally brought to the attention of Congress by the Hon. H. E. Paine, of Wisconsin, who offered the following joint resolution, which became a law on the 9th of February, 1870.

[PUBLIC RESOLUTION No. 9.]

Be it resolved, &c., That the Secretary of War be, and he is hereby, authorized and required to provide for taking meteorological observations at the military stations in the interior of the continent, and at other points in the States and Territories of the United States, and for giving notice on the northern lakes and on the sea-coast, by magnetic telegraph and marine signals, of the approach and force of storms.

By General Orders No. 29, from the headquarters of the Army, March 15, 1870, issued by the authority of the Hon. William W. Belknap, Secretary of War, Bvt. Brig. Gen. A. J. Myer, the Chief Signal-Officer

of the Army, was charged, subject to the direction of the Secretary of War, with the execution of this enactment, and as the undertaking is for the benefit of the commerce of the United States, all commanding officers are required and all scientific institutions requested to aid by their co-operation in its accomplishment.

The text of the order is as follows:

The Chief Signal-Officer of the Army is charged, subject to the direction of the Secretary of War, with the special duties of the observation and giving notice, by telegraph and signal, of the approach and force of storms, under the provisions of this resolution.

The undertaking thus imposed upon the Secretary of War is for the benefit of the commerce of the United States. It is therefore expected that all commanding officers will afford every facility for its successful discharge; and all scientific establishments, commercial associations, and others, are requested to aid by their co-operation in its accomplishment.

The fact that in the north temperate zone storms almost invariably come from some westerly point and follow an easterly course renders the application of storm-warnings in the United States of more immediate utility than in Europe, where the principal points, being on the eastern coast, are first affected by the storms. Here, as soon as a storm appears in the territory bordering on the Rocky Mountains, it becomes possible in many cases, with proper arrangements, to telegraph its approach to eastern cities in time to enable preparations being made against its destructive influence. It is not absolutely necessary that the observers or reporters should be scientific men, though the higher their grade of education the better, but that they should promptly announce the existence of a storm with other meteorological facts to the places lying within its probable path. It is essential that they should be held to a proper responsibility and be under strict official control. The form of report must be carefully devised and regulated. A series of reports of this kind will make possible in time the mapping out of each individual storm, and from this material can be deduced some general laws governing their movement.

The system inaugurated by Congress was designed for the protection of the seaboard as well as the lake districts. It was hoped to extend its benefits to all the coasts, and, by the necessary stations, to the great navigable rivers of the United States.

The plan so far determined by the War Department contemplated the simultaneous observation of atmospheric phenomena, the telegraphic transmission of reports of these observations, and the wide-spread publication of the reports at all points where they would be of service to the commercial interests of the country.

Full effect was given by the War Department to the action of Congress in this matter, in order to make it of the widest utility. The organization was rapidly effected, observers instructed and supplied with instruments, and minute arrangements made with the telegraph companies for the transmission of the reports. The practical co-operation

of chambers of commerce, boards of trade, of underwriters, and of scientific establishments was sought. The press was furnished reports gratuitously, to render their diffusion as general and speedy as possible.

The organization of a division of telegrams and reports for the benefit of commerce having been provided for, and stations having been selected and supplied with the necessary instruments, the practical working of the system was at once begun, and on the 1st of November, 1870, at 7.35 a. m., the readings of the instruments at twenty-four stations were taken by the observers, and placed upon the telegraph wires for transmission to the central office at Washington, D. C. These reports, the first systematized, synchronous meteoric reports ever taken in the United States, were at once bulletined and furnished by telegraph at twenty-four cities. On the 8th of November, 1870, the first storm-warning was telegraphed and bulletined along the lakes. During the winter of 1870–'71, the extension of the system of stations progressed rapidly. The East Atlantic coast, the section from Chicago to San Francisco, the Gulf of Mexico, and the valleys of the Ohio and Mississippi Rivers were supplied with stations, and the reports received therefrom were bulletined and published in the different cities. Each succeeding year saw the opening of new stations of observation, and at the present time tri-daily reports are received from different localities in the United States. Upon these reports are based the synopsis and probabilities issued by the central office three times daily. The synopsis consists of a synoptic view of the weather condition of the United States, as had from the data received at each regular report. The probabilities are the deductions made by the office from the data in its possession, at the time of each report, as to the weather conditions probable in the eight hours following the receipt of the report. Copies of these synopses and probabilities are furnished at the moment of their issue to the different press associations throughout the country. They are also printed on graphic weather charts issued tri-daily from the office at Washington, and once daily from certain other stations, and which exhibit by printed symbols and figures the meteoric conditions at the various signal stations. These stations are in charge of enlisted men of the Signal Service who have undergone a course of instruction at the Signal Service School of Instruction at Fort Whipple, Va. Each station reads its instruments seven times during the twenty-four hours, viz, 7 a. m., local time; 7.35 a. m., Washington time; 12 m., Washington time; 2 p. m., local time; 4.35 p. m., Washington time; 9 p. m., local time; 11 p. m., Washington time; and during the passage of storms over stations numerous observations are made. Four of these readings are local observations, the remaining three, viz, 7.35 a. m., 4.35 p. m., and 11 p. m., Washington time, are telegraphic. These latter are at once transmitted to the Washington office. In order to make the telegrams as brief as possible, and with a view to guard against error likely to occur in transmitting numbers, a cipher has been adopted, the different possible read-

ings of the instrument having their corresponding word. The observations, having been taken and reduced, are at once enciphered by the observer and transmitted to Washington. Upon their receipt they are deciphered and turned over to the officer who is engaged in making out the synopses and probabilities during that month.

The average time elapsing from the time at which the readings of the instruments have been had at the stations to that at which the reports based on these readings have been telegraphed to the press and to the distributing stations has been one hour and forty minutes.

Each station is supplied with the following instruments: 2 standard barometers, 2 standard thermometers, 1 standard hygrometer, 1 maximum thermometer, 1 minimum thermometer, 1 anemometer with self-registering attachment, 1 wind-vane, 1 rain-gauge, 1 clock.

The following reports are published and exposed at the various stations.

Daily Bulletin, of reports from the various stations, received, written out, and posted throughout the city at intervals of eight hours.

Synopsis and Probabilities (Farmers' Bulletin), showing the actual state of the weather throughout the continent and the weather likely to be, also received and exposed at intervals of eight hours.

Graphic Weather Charts, printed or stamped on stations once daily, showing by symbols and figures the weather conditions at the various stations of the United States.

Local Readings of instruments for publication in the newspapers.

River Reports (published at river stations), being reports of the rise and fall in such rivers as affect the commerce of the locality. Such general or special information affecting the locality as may be ordered published by the Chief Signal-Officer.

The proper hour having arrived, the observer reads his instruments in the following order: Barometer, anemometer, thermometer, anemoscope, hygrometer, rain-gauge. The character, direction, and velocity of the upper and lower clouds are also taken. Each reading, when made, is entered in the original record of observations. The report is then corrected and reduced, and if a telegraphic report, it is translated into cipher and transmitted by telegraph to Washington.

All reports, telegraphic and local, are entered in the meteorological record of the station.

The sea-coast service of the Signal Service is connected with the Life-Saving Service. Five hundred and forty-three miles of sea-coast lines have been constructed by the Signal Office and intermediate stations established for keeping the coast and sea under constant observation, for giving warning of approaching storms to vessels that are within signal distance, and for conveying rapidly by the telegraph lines to the chain of life-saving stations, to light-houses and to ports from which aid may come in case of need, information of disasters or other incidents. The enlisted men employed upon this duty have been taught to take and re-

port meteorological observations, and as signal men are practiced, in both the Army and Navy codes, in the use of semaphores, and in the code of permanent flag-signals known as the international code, to enable them to communicate with vessels of any nationality.

At lake or coast stations, cautionary signals are displayed, indicating the approach of storms. These signals are ordered "up" or "down" by the Chief Signal-Officer, and are the result of examinations of reports received from the different stations. A wind blowing at the rate of 25 miles an hour is considered a justification of the order to display the storm-warning. The cautionary signal consists of a red flag with black square center by day; by night a red light, and is displayed from some prominent point in the city or port. All of the meteorological data collected at the stations is transmitted to the central office at Washington. It is here examined and discussed; such as is of immediate use is distributed throughout the continent by means of the telegraph wires; the rest is made use of in the compilation of various charts and weather reviews, and in the study of the meteorology of the United States, and the general results thus obtained are published and distributed.

In 1873, at the Congress of Meteorologists, held at Vienna, Austria, the Chief Signal-Officer proposed the taking of simultaneous observations throughout the world. The proposition was approved, and to-day these meteorological observations are transmitted by mail to Washington, and there collected and published in the International Bulletin and the International Weather Map, thus obtaining and preserving records which enable atmospheric movements to be advantageously studied.

In compliance with a request made by the Chief Signal-Officer of the Army for a co-operation of the Navy Department with the War Department in extending the system of simultaneous international observations on board naval vessels and at stations, the Secretary of the Navy has directed the commandants of all naval stations, and the commanding officers of all vessels of war of the United States, to cause observations to be taken and recorded daily at 7.35 a. m., Washington mean time; these observations to form part of the International Bulletin and International Weather Map issued by the Signal Service.

The following is a list of the principal publications issued from the office of the Chief Signal-Officer:

Daily Bulletin of weather reports received from the various signal stations in the United States, issued every eight hours.

Weather Maps, with printed symbols and figures, issued every eight hours, and based upon the daily bulletin.

Weekly Weather Chronicle, published every week, and containing a review of the storms, changes of temperature, rainfall, rise or fall of rivers, &c.

Monthly Weather Review, published each month, which reviews and discusses the meteorological data obtained.

International Bulletins, published daily, containing simultaneous re-

ports received from the following countries of the world, viz: Algeria, Austria, Belgium, Great Britain, Denmark, France, Germany, Greece, Italy, Japan, Netherlands, Norway, Portugal, Russia, Spain, Sweden, Switzerland, Turkey, Canada, United States, Cuba, Bermudas, the Hawaiian Islands, Dutch Guiana, and United States naval vessels and stations througout the world.

International Weather Map, based upon the International Bulletin.

Annual Report of the Chief Signal-Officer, made to the Secretary of War at the close of each fiscal year, containing review of the work of the year; meteorological data obtained by the stations, original papers on meteorological subjects, maps, charts, &c.

Copies of these publications and of meteorological charts bearing upon the climate and storms of the United States were exposed in the section for general inspection by the public.

As before stated, no complete exhibit of signal apparatus was made by any of the Governments that participated in the International Exhibition. In the department of New South Wales, British section, was found an adaptation of the heliostat, used in trigonometrical surveying operations. The instrument, called *sematrope*, was designed by Lieutenant Parrott, Volunteer Engineers, New South Wales, expressly for signal purposes, who claims that it can be used with facility, under moderately favorable atmospheric conditions, for transmitting messages over a distance of 50 miles, by means of the reflected light of the sun, and over 8 miles by reflected moon rays. The sematrope mirror is curved in order to overcome the difficulty arising from the apparent motion of the sun, which is constantly changing the direction of the rays reflected from its surface. The effect of the curve is to disperse the rays to such an extent as will materially increase the length of time during which flashes can be made without readjustment, and it is claimed without reducing to any serious degree the brilliancy of the light. The movable portion of the instrument is fixed to a cast-iron base, around the top of which a mirror is made to revolve, and to which it is firmly clamped when in position. In order to direct the rays without moving the mirror, a lens tube has been so arranged as to work independently of the mirror, and revolves around the upper part of the cast-iron base upon a curved arm, the center of which coincides with the center of the mirror, to which point it is, therefore, always directed. The flashes of light are made visible by means of a movable cover to the mirror. By the courtesy of the commissioner from New South Wales, Lieutenant Parrott's instrument was loaned to the Chief Signal-Officer of the Army for examination.

In the collections of the Russian ministry of war were exposed:

1st. The drawings of a field telegraph train showing only the *construction* of wagons for a 70 mile line; and,

2d. The Taboulevitch signal lamp.

Regarding the former, it appears from such information as could be

gathered from the drawings that the wagons are strongly built, heavier than those used in the United States Army, and well calculated to stand the wear and tear of military service. Russia has adopted the Prussian system of field telegraph.

THE TABOULEVITCH SIGNAL LAMP,

Devised by Lieutenant Taboulevitch, of the Russian Imperial Navy, is designed for naval use. A lamp of smaller dimensions, but not on exhibition, based upon the same principle, has been constructed with a view to its adaptation to army signaling. The system consists in burning pulverized turpentine, and the brilliant flame produced is thrown out in long or short flashes, the combining of these flashes being similar to the dots and dashes of the Morse telegraph code, or to the numerals 1 and 2 of the Signal-Service Code of the United States Army. By means of a bellows, which requires but little motive power, and which is connected with the lamp proper by an India-rubber tube, the jet of turpentine is forced through what is called a pulverizer. This transforms the liquid into a fine spray, after which it passes out above the lantern in a stream 3 feet in length, coming in contact with the flame of a spirit lamp. The turpentine spray is thereby ignited, and the flame obtained is an exceedingly brilliant one. It is claimed that the arrangement of the several parts of the lamp prevents the turpentine reservoir from becoming heated; that the spirit lamp which ignites the signal jet cannot be extinguished by the wind, and that the flame may be shortened or lengthened from 1 to 3 feet, as may be desired. In case of a strong wind, a perforated sheet-iron cylinder is attached to the upper part of the lantern, thereby preventing the signal flame from being bent down. A special committee, by order of the Russian admiralty, whilst examining this lamp, made different experiments for the purpose of ascertaining this visibility of signals produced at various distances, and it was found that flashes made in St. Petersburg were visible and easily read at Cronstadt, a distance of more than 16 miles. Should the signal-lamp be placed on some elevated point, as on the mast of a vessel, the bellows need not be removed from the deck, as the short India-rubber tube which runs from the bellows to the pulverizer can be replaced by a longer one.

Through the kindness of Capt. L. P. Semetchkin, Russian Imperial Navy, an opportunity was afforded to see the signal lamp in operation, though, of course, no test of visibility could be made. The working qualities of the lamp were most satisfactory. The flame was an exceedingly brilliant one, and the production of long or short flashes required no skill or previous practice on the part of the operator.

FIELD GLASSES.

A careful examination was made of the field telescopes and field glasses (binocular) exhibited by the different manufacturers, and this examination consisted in practically testing such as appeared to best

answer the requirements of the Army. The examination was made for a double purpose; 1st, to obtain the comparative value of the glasses now used in the Signal Service as signal glasses, and to ascertain if improvements had been made; and, 2d, to secure a suitable field glass for the ordinary use of officers in the field, and, though of less power than the Signal-Service binocular glass, sufficiently small to be of light weight and easily carried. The military glass described below, manufactured by Messrs. Bardou & Co., of Paris, is specially recommended to officers of the Army. It was adopted by the French ministry of war after a competitive trial of glasses submitted by seventeen of the leading manufacturers of France. Its power is greater than that found in the average large size-glass; the supply of light is excellent, as is also the definition, and the field of vision is six-sevenths of the large field glass now used in the Signal Service of the Army. It is strongly made in conical or taper shaped body, metal work bronzed, and the body covered with morocco stitched together at the edges, contained in a solid leather case supplied with both shoulder strap and loop for waist belt, enabling it to be worn either way: Object lens, 19 lines, or $1\frac{11}{16}$ inches; magnifying power, $5\frac{1}{2}$ times. The agents in this country are Messrs. Sussfeld, Lorsch & Co., No. 13 Maiden Lane, New York.

Neither field telescopes nor field glasses were found at the Exhibition which could advantageously be substituted for those now used in the Signal Service of the Army.

Messrs. Dalmeyer & Co., of London, exhibited a portable field telescope holder or stand, made in the form of a metallic tripod 3 feet high.

AERIAL LADDERS.

In connection with military field signal apparatus, attention is invited to the Scott-Uda Aerial Ladder, a test of which occurred on the 9th of September in front of the Government building and which was subsequently repeated (the ladder having been placed at the disposal of the Signal Service section), and the possibility of using these ladders for signal purposes in the field is suggested. The one exhibited was of the same height as the Davis signal tower now being tested by the Chief Signal-Officer, viz, 75 feet. It was prepared for work in two minutes and thirty seconds, which included taking the several sections from the wagon, their distribution on the ground, jointing together in one continuous ladder, and elevation to its full height. In this position it was put through various tests. A light movable platform of the size required for signal purposes could be readily constructed and attached to the upper section, and, by means of rope guys, sufficient steadiness might be obtained to enable observations to be made with the telescope. These ladders are of various heights, from 25 to 125 feet. The following are some of the advantages which they offer over the signal tower: Less working force required for their care and elevation; less liability

become unserviceable; greater rapidity of elevation, the 125 feet ladder requiring but 3 minutes and 40 seconds, much less weight, and, in case of breakage of any of the parts, more easily repaired. Moreover, by using two ladders, the tongues of the wagons facing and the ladders inclining towards and mutually bracing each other when the platform boards and braces were attached, an observation and signal station would be secured, capable of being erected on uneven ground within ten minutes, and furnishing a lookout from an elevation of 125 feet.

METEOROLOGICAL INSTRUMENTS.

Regarding the display of meteorological instruments at the exhibition, all the principal makers of Europe and the United States appeared to be well represented, and those described, or referred to below, have been selected on account of improvements introduced in their manufacture, and the possibility of their being used in the United States Signal Service. Among the most noteworthy scientific instruments at the exhibition was—

THEORELL'S PRINTING METEOROGRAPH,

invented by Dr. A. J. Theorell, of Upsala, Sweden, and constructed by Mr. Sörensen, instrument maker to the Academy of Sciences of Sweden. The readings of the several instruments composing the meteorograph are printed by the working of the instrument on a slip of paper. Of the six tabular columns, the first gives the hours; the second, the velocity of the wind; the third, the direction of the same; the fourth, the temperature; the fifth, the degree of humidity, according to August's method; and the sixth, the atmospheric pressure in millimeters. The degrees of the thermometer employed are those of the centigrade scale, and negative degrees are expressed by their complements of 100. The direction of the wind is indicated by figures from 1 to 32. The numbers expressing the velocity of the wind signify meters in a second. The registering portion of the meteorograph and the mercurial barometer were indoors, the wind-vane and anemometer were exposed to the action of the wind on the roof of a large instrument shelter, and the two thermometers (wet and dry bulb) were inside the shelter, their open upper ends being inclosed in a longitudinal zinc box with a glass side and front, from which the air was exhausted, and which also contained the magnets required for these instruments.

The registration takes place by means of electric currents, which are closed in the barometer and both the thermometers by contact between the mercury and steel wires that descend into their tubes, and at the wind-vane and anemometer, by contact between a metal knob put in motion by the current and a wheel, which is connected mechanically with each of these instruments. The steel wires in the barometer and

in both the thermometers are connected, each by its system of brass wheels, with numerical types engraved on the edges, in such a manner that the rotation of the wheels causes an upward or downward motion of the steel wires, so that the point of the scale, on which the lower extremity of the wire is situated, is necessarily that indicated by the number appearing at the same moment uppermost on the corresponding wheels. The two other brass wheels with engraved figures are likewise combined, by means of electric currents, with the above-mentioned metal knobs in the wind vane and the anemometer, in such a manner that the figure, which is uppermost on the periphery of the wheels at the moment it is about to be registered, indicates the direction of the wind at the same moment, and its mean force during the preceding quarter of an hour.

The wheels containing the figures are governed by an electro-magnetic motor, which, for each observation, sets the five systems successively in motion, until the corresponding wires have reached the quicksilver in the barometer and the two thermometers, and caused contact between the metal knob in the vane and the anemometer, and the wheels, which are in mechanical combination with each of these instruments.

The numbers, therefore, that are uppermost on the numbered wheels are just those which indicate the height of the barometer, and of the two thermometers, as well as the direction and velocity of the wind. The same electro-magnetic motor operates upon a printing apparatus, which, after having deposited color on the types, presses the slip of paper against them. This being done, the steel wires are drawn up again by the motor, which stops as soon as a certain distance from the quicksilver is attained, and all is ready for the next observation. The interval between the observations is a quarter of an hour.

It is stated that a large number of comparisons very carefully made have shown that the observations registered with the aid of the method here employed have an accuracy equal to that usually attainable by ocular observations.

The zinc vessel in which the upper ends of the thermometers are inclosed is air-tight, and it has been found possible, by means of chloride of lime and caustic potash, to keep the inclosed air always free from damp and carbonic acid, a necessary precaution in every climate where the temperature is liable to sink below the freezing point. This also protects both the quicksilver and the steel wires from oxidation and preserves the galvanic contact. It is also stated that a meteorograph of this construction has been used at Upsala observatory for two years, and that during that time it has made four observations every hour without causing any perceptible change in the surface of the quicksilver or in the steel wires, that could, in any way, affect either the efficiency of the instrument or its accuracy.

As the clock which determines the time of the observations does not

require winding up, the instrument itself restoring the tension of the mainspring every quarter of an hour, it continues going as long as the impellent force, *i. e.*, the electric current, is maintained, and as the slip of paper applied lasts for fully three months, it is clear that that is the period for which the instrument may be left to itself.

A printing meteorograph, differing from the above only in that the latter has been improved and perfected in several details, has been constructed by the same mechanician, Mr. Sörensen, for the Imperial Central Establishment of Meteorology in Vienna. A description of this meteorograph is inserted in "Zeitschrift der Österreichischen Gesellschaft für Meteorologie, redigirt von C. Jelinek und J. Hann." Volume X, No. 16 and 17.

Up to the present time, four of the Theorell's meteorographs have been constructed and are located; 1 at Vienna, 2 at Upsala, and 1 at Copenhagen. It is suggested that some of the difficulties of obtaining meteorological observations by exploring parties in the Arctic regions might be overcome by using meteorographs.

Finally, it may be remarked, that the principle on which this instrument has been constructed may be adopted with the same advantage for observing the particulars of any other phenomenon, provided they can be indicated by an index which produces a galvanic current.

ANEROID BAROMETER.

The aneroid as an instrument for obtaining elevations is, and will probably always remain, secondary to the cistern-barometer, but becomes a valuable substitute when the latter cannot be obtained or carried, as during rapid military reconnaissances, or when the mercurial instrument would be exposed to breakage from rough handling. Careful experiments have proved that in order to render the observations of the aneroid reliable, the instrument must be compared with the standard, not only previous to the beginning of field-work, but also upon the return at the completion of the work, for an agreement with the standard is not constant, but varies under great changes of atmospheric pressure, and when differences of elevation have been experienced. An examination of the many thousands of comparative readings made by officers of the Signal Service while inspecting the various Signal Service stations throughout the United States, shows that where portability is a desideratum and extreme accuracy not indispensable, the aneroid will give satisfactory results. If forming part of an officer's outfit on scouts or on detached service in unexplored country, or through country that has not been mapped, its observations for elevation will increase the value of an official report, and will be all the more accurate, if, by comparison with a standard mercurial barometer upon return to the station, the instrumental error, or new variation of the aneroid, can be obtained.

The display of these instruments at the exhibition was all that could be desired, the leading makers of Great Britain and France being particularly well represented. Negretti & Zambra, Hicks, Lion and Guichard, and other firms of Europe, exhibited aneroids of all sizes, from the pocket instrument 1½-inch in diameter, to those designed for exposure on public buildings or monuments, and of such diameter (3 feet) as to render their readings plainly visible from a distance, the one class graduated to indicate elevations above sea-level or the depths of mines, the other to act as weather glasses. In connection with the latter class, and with reference to their remarkable sensitiveness as weather indicators, it may not be inappropriate to call attention to the testimony of some of the greatest meteorologists that England has produced. Such men as the late Admiral Fitzroy, Col. Sir Henry James, Mr. Glaisher, Mr. Belville, and Sir Leopold McClintock, give, as the result of their experiments, that atmospheric changes are indicated first by the aneroid, that its movements are always consistent and may be safely depended upon, that it is quick in showing the variation of atmospheric pressure, and that as a weather glass it is the best form of barometer that has been made. In some portions of Europe large-size aneroid barometers are exposed on the public buildings for the purpose of serving as weather indicators. These instruments are manufactured by Messrs. Lion and Guichard, No 8, Rue de Rocroy, Paris, from whose price lists the following extracts are made:

Diameter 0.67 millimeter	$43
Diameter 0.80 millimeter	46
Diameter 0.90 millimeter	55
Diameter 1.00 millimeter	60

MINIMUM THERMOMETER (HICKS').

Among the exhibits in the British section was found a minimum thermometer (Fig. 2), made by J. J. Hicks, meteorological-instrument

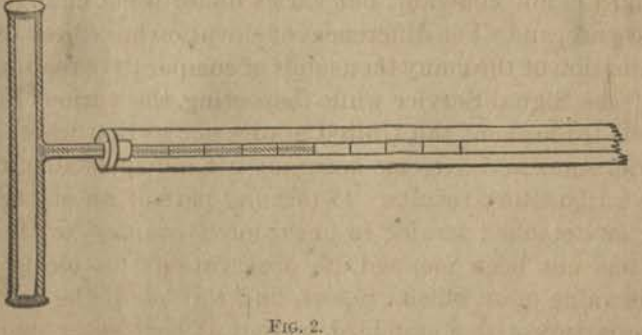


FIG. 2.

maker of London, and to which he has given the name "cylinder jacket" minimum thermometer. The improvement consists in the construction

Fig. 3.

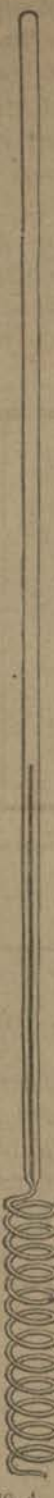


Fig. 4.

of the bulb, so as to reduce its cubical contents and to present a larger surface than does the spherical bulb to the air or liquid of which it is desired to obtain the temperature. The bulb consists of a long, hollow, glass cylinder, around which a second cylinder is blown, the open ends of the two being united. This leaves a thin space between them to contain the spirit. The stem of the thermometer is attached to the center of the outer cylinder. This instrument has been tested at the Kew Observatory with very satisfactory results, and is commended on account of its sensitiveness. Alcohol, or spirit thermometers, constructed with globular bulbs, are slow to record sudden changes of temperature compared with the mercurial thermometer. The improvement of Mr. Hicks furnishes a spirit thermometer, said to be almost equal in sensitiveness to a standard mercurial.

MERCURIAL THERMOMETERS.

There were exhibited by the same manufacturer two highly sensitive mercurial thermometers. In these instruments the bulbs are gridiron and spiral shaped, the former having sufficient range to enable readings to be made to one-tenth of a degree. Both instruments were secured for the Signal Office (Figs. 3 and 4).

A new solar radiation thermometer was also noticed, in which the perfection of the vacua can be tested by a Ruhmkorff coil and an exhaustion produced to within one-twentieth of an inch of perfection.

Messrs. Negretti & Zambra, of London, exhibit a self-recording atmospheric thermometer, which appears to be worthy of notice and trial.

The principle carried out in the construction of this instrument is the

same as has been applied to a deep-sea self-registering thermometer, also devised and exhibited by these manufacturers. The thermometer, of syphon shape (Fig. 5), is connected at its center with a clock movement. The clock being set at the hour for which the temperature reading is desired, when the proper moment arrives, by the release of a spring in the clock, the thermometer is reversed and the mercury in the left-hand branch is thrown into the registering tube. Wet and dry bulb hygrometers can also be arranged on the same plan.

Should hourly or half-hourly records of the variations of the temperature be desired, or any fractional part of an hour, the necessary number of thermometers can be placed on a frame and reversed at the proper

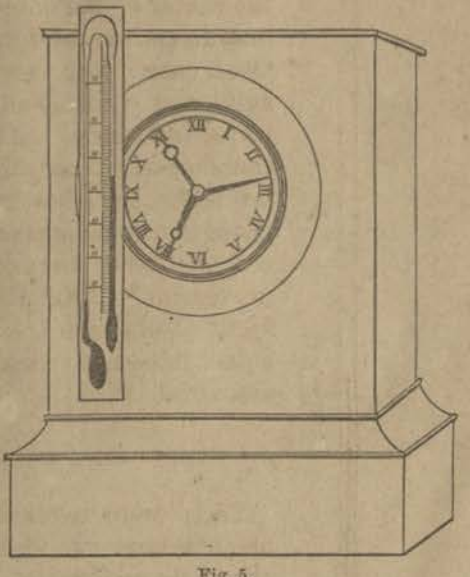


Fig. 5.

time by clock-work. The exhibit of Messrs. Negretti & Zambra was, as could be expected, an exceedingly fine one. It is not considered necessary to make any detailed description of instruments that have been already furnished to the Signal Office by these manufacturers.

James J. Hicks exhibited a new mercurial barometer, in which the Fortin system has been replaced by a thin flattened glass sphere to which the barometer tube is attached, having the general appearance of a large-size thermometer with flattened bulb. The atmospheric pressure upon the bulb causes the rise or fall of the mercurial column. This instrument would not be suitable for use in the Signal Service.

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